# Habitat Expansion Agreement for Central Valley Spring-Run Chinook Salmon and California Central Valley Steelhead

## Draft Habitat Expansion Plan

November 2009

**Prepared by**
California Department of Water Resources
and
Pacific Gas and Electric Company

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# Executive Summary

Effective November 20, 2007, Pacific Gas and Electric Company (PG&E) and the California Department of Water Resources (DWR) entered into the *Habitat Expansion Agreement for Central Valley Spring-Run Chinook Salmon and California Central Valley Steelhead* (HEA) with the following parties: American Rivers; Arthur Baggett, Jr.; California Department of Fish and Game (DFG); U.S. Department of Agriculture Forest Service; National Marine Fisheries Service (NMFS); U.S. Fish and Wildlife Service (USFWS); and State Water Contractors, Inc. DWR and PG&E (Licensees) formed a Steering Committee to implement the HEA in accordance with its terms and conditions.

The HEA allows the Licensees 2 years to jointly identify, evaluate, and select the most promising and cost-effective action(s) to expand spawning, rearing, and adult holding habitat for spring-run Chinook salmon and steelhead in the Sacramento River basin. These actions are proposed as an alternative to NMFS exercising its Section 18 authority under the Federal Power Act (FPA) to require fish passage past Oroville Dam in the new Federal Energy Regulatory Commission (FERC) licenses for DWR's Oroville Facilities Project and PG&E's Upper North Fork Feather River Hydroelectric Project and Poe Hydroelectric Project (Feather River Hydroelectric Projects), all of which are located on the Feather River.

This draft Habitat Expansion Plan (HEP) describes how the first phase of the HEA has been implemented; presents the Licensees' recommended actions; and describes each action in detail, including its estimated contribution to the Habitat Expansion Threshold (HET) specified in the HEA, a pre-feasibility cost estimate, a proposed implementation schedule, the responsibilities of each Licensee, and the rationale for selecting the actions. This draft HEP also describes outreach activities that the Licensees have taken to keep the HEA signatories and other stakeholders informed about and involved in the HEA process. Finally, this draft HEP explains the remaining phases of implementing the HEA.

## HEA Goals

The overall goal of the HEA (Section 2.1 of the HEA, "Goal of Agreement") is to expand habitat with the physical characteristics necessary to support spawning, rearing, and adult holding of spring-run Chinook salmon and steelhead in the Sacramento River basin as a contribution to the conservation and recovery of these species. Habitat expansion is to be accomplished through enhancements to

existing accessible habitat, improving access to habitat, or other habitat expansion action(s) and is intended to mitigate for any presently unmitigated impacts due to the blockage of passage of all fish species caused by the Feather River Hydroelectric Projects.

The specific goal of the HEA (Section 2.2 of the HEA, "Habitat Expansion Threshold") is to expand spawning, rearing, and adult holding habitat sufficiently to accommodate an estimated net increase of 2,000 to 3,000 spring-run Chinook salmon for spawning in the Sacramento River Basin, as compared to the habitat available under any relevant existing requirements or commitments (i.e., actions expected to occur in a timeframe comparable to implementation of habitat expansion action[s] under the HEA). This specific goal is referred to as the HET.

# HEA Criteria

The HEA identifies several criteria for identifying, evaluating, recommending, and approving habitat expansion actions, including:

- HEA Evaluation Criteria (Section 4.1.1 of the HEA),
- HEA Selection Criteria (Section 4.1.2 of the HEA), and
- NMFS Approval Criteria (Section 4.2.3 of the HEA).

The Licensees developed working definitions for the various HEA criteria (Appendix B) to facilitate utilization of these criteria for selecting actions to be included in the HEP. Criteria definitions draw on the concepts described in the HEA, current scientific literature, recovery plans, and other sources. The Licensees requested feedback on the working definitions from NMFS, the HEA signatories, and other interested stakeholders to further develop these definitions in order to consistently apply the criteria when identifying, evaluating, and recommending habitat expansion actions. Chapter 3 of this plan describes the approach used by the Licensees in applying the HEA Evaluation and Selection Criteria to the potential habitat expansion actions and selecting the recommended actions.

The Licensees developed an initial list of almost 200 potential actions drawing from existing plans and projects identified by others, as well as input from the signatories and other stakeholders. The HEA Evaluation Criteria were applied to a shortened version of the initial list to develop a Ranked Preliminary List of Viable Actions, and the Selection Criteria were then applied to this list to develop a Ranked List of Viable Actions. Based on how they rated against the overall HEA Criteria, actions were selected from the Ranked List of Viable Actions to become recommended actions.

# Contribution to the HET

The Licensees developed an approach to evaluate the contribution of each action to the HET that reflected: (1) the limited timeframe allowed under the HEA; and (2) the recognition that data related to habitat characteristics in the Sacramento River system are generally lacking and vary greatly in detail between watersheds. A qualitative approach was devised that used empirical data, as well as the professional judgment of the Steering Committee Technical Team and other experts. The HET contribution procedure utilizes a series of logical steps and a set of assumptions that support conclusions regarding the potential of recommended actions to provide habitat in order to achieve the HET. The procedure offers a consistent and relative approach to comparing the potential contribution of actions to the HET. The results of applying this procedure to the recommended actions in the watersheds are provided in Appendix E. As stated in Section 6.1 of the HEA, the Licensees are not obligated to guarantee or verify fish production or habitat utilization. The estimated contribution of an action to the HET represents an index of the increase in quality and quantity of habitat for spring-run Chinook salmon. Actual results of the actions could differ due to a variety of factors.

# Recommended Actions

The Licensees identified two groupings of habitat expansion and enhancement actions that each meet the goals, terms, and conditions of the HEA: (1) the Lower Yuba River Habitat Expansion Actions (Lower Yuba River Actions); and (2) the Battle Creek, Big Chico Creek, and Antelope Creek Habitat Expansion Actions (Three-Creek Actions). The Licensees propose that one of these two groups of actions be implemented under the HEA. Each group of actions is briefly described in Chapter 5, along with the rationale for recommending the group of actions and a discussion of potential issues related to their review under this phase of the HEA. Detailed descriptions of each of the individual actions that make up each group of actions are given in Chapters 6 through 9.

As previously stated, the Licensees evaluated a large number of potential actions for possible inclusion in this draft HEP and believe that the recommended groups of actions are the best actions to put forward to meet the HET and to ensure the success of the HEA in providing expanded habitat for spring-run Chinook salmon. As required by Section 4.1.3 of the HEA, the Licensees are submitting both of these groups of actions for review and comment by the HEA signatories and other stakeholders. Once comments are received, the Licensees expect to select one of the two groups of actions, as may be modified in response to comments received, and propose this group of actions in the final HEP. NMFS will then determine whether to approve the actions selected in the final HEP by applying the NMFS Approval Criteria specified in the HEA.

# Lower Yuba River Habitat Expansion Actions

Application of the HEA criteria to the Ranked List of Viable Actions and estimation of the contribution of these actions to the HET led to identification of a group of actions on the Lower Yuba River that, when combined, would meet the overall goals, terms and conditions of the HEA. This group of actions is referred to in this document as the Lower Yuba River Habitat Expansion Actions (Lower Yuba River Actions). The individual actions that make up the Lower Yuba River Actions consist of the following:

- rehabilitate spawning habitat in the Englebright Dam reach of the lower Yuba River and augment gravel in lower Deer Creek (a tributary to Yuba River);
- plan for, and if necessary, install a segregation weir at a location in the 6-mile reach between Englebright Dam and the Highway 20 Bridge; and
- restore juvenile rearing habitat between the Highway 20 Bridge and the downstream extent of the Yuba Goldfields.

The Lower Yuba River Actions would provide additional habitat between Englebright Dam and Daguerre Point Dam that would support spawning, rearing, and adult holding of spring-run Chinook salmon—in addition to ancillary benefits to steelhead. This group of actions is estimated to expand the habitat sufficiently to accommodate a net increase of approximately 3,450 spring-run Chinook salmon and, furthermore, may lead to establishing a new, independent population.

The estimated contribution to the HET for the Lower Yuba River Actions is the highest of all of the actions considered. The actions also rate favorably on a number of the HEA Evaluation Criteria and appear to be the most cost effective, although a significant amount of effort remains to develop a detailed description of the actions. The Licensees plan to continue working with the signatories and active watershed groups who have been considering these actions for a number of years to further develop details of the actions. In particular, additional outreach with more stakeholders in the watershed will be necessary before the HEP can be finalized. Provisions for ongoing operations and maintenance would be negotiated with the stakeholders as appropriate, given that most Lower Yuba River Actions would be located on property that is not owned by either Licensee. When the final HEP is approved, the Licensees are confident that—with the support of the signatories and other stakeholders—the Lower Yuba River Actions could be implemented within a reasonable time frame (i.e., within 5 years), with a benefit to spring-run Chinook realized in less than 10 years. In summary, the Lower Yuba River Actions represent an excellent opportunity to meet the goals, terms, and conditions of the HEA.

Table ES-1 summarizes the attributes assigned to the Lower Yuba River Actions by the Licensees, as well as an evaluation of these actions based on applying the NMFS Approval Criteria specified in the HEA. Approval of the final HEP will

be determined by NMFS, after input from the HEA signatories and other stakeholders, using the Approval Criteria.

**Table ES-1.** Application of NMFS Approval Criteria to Lower Yuba River Habitat Expansion Actions (Lower Yuba River Actions)

| Action Attributes | Lower Yuba River Actions |
|---|---|
| Estimated contribution to the HET | ~3,450 adult spring-run Chinook salmon[a] |
| Estimated cost | ~$20.6 million[b] |
| **NMFS Approval Criteria Evaluation[c]** | |
| Assures necessary testing, operations and maintenance? | Yes |
| Supports establishing geographically separate self-sustaining population?[d] | Yes |
| Supports segregating spring-run from fall-run?[d] | Yes[e] |
| Eligible? | Yes |
| Expected to be implemented in a reasonable period of time? | Yes |

Note: Lower Yuba River Habitat Expansion Actions (Lower Yuba River Actions) consist of rehabilitating spawning habitat in the Englebright Dam reach of the Lower Yuba River and augmenting gravel in lower Deer Creek (a tributary to Yuba River); planning for and, if necessary, installing a segregation weir at a location in the 6-mile reach between Englebright Dam and the Highway 20 Bridge; and restoring juvenile rearing habitat between the Highway 20 Bridge and the downstream extent of the Yuba Goldfields.

[a] Values reflect the number of adult fish supported by habitat expansion. The estimated contribution of an action to the Habitat Expansion Threshold represents an index of the increase in quality and quantity of habitat for spring-run Chinook salmon. Actual results of the actions could differ due to a variety of factors.

[b] A 20% contingency was added to the estimate due to uncertainties in available cost information.

[c] Evaluation applies to the group of three actions, not necessarily each of the individual actions.

[d] Criterion not required for approval.

[e] Segregation may occur naturally or, if necessary, with the installation of a proposed segregation weir.

## Eligibility

The HEA allows for a variety of actions to be considered eligible for inclusion in the HEP. Actions identified in other venues, including unfunded actions, are acceptable for consideration, provided implementation results in a net expansion of habitat over any existing requirements and commitments. These are defined in Section 3.2 of the HEA and may include, but are not limited to, legal or regulatory requirements subject to a binding order, action by an agency or court, relicensing proceedings, or existing biological opinions.

On November 21, 2007, NMFS issued a biological opinion to the U.S. Army Corp of Engineers (Corps) to address the effects of operations on spring-run Chinook salmon (and other species) at both Englebright and Daguerre Point Dams. In the biological opinion, NMFS issued an incidental take statement with a number of Reasonable and Prudent Measures, including the following:

1. *The Corps shall develop and implement a long-term gravel augmentation program to restore quality spawning habitat below Englebright Dam.*

   A) *The Corps shall utilize the information obtained from the pilot gravel injection project to develop and commence implementation of a long-term gravel augmentation program within three years of the issuance of this biological opinion.*

The large-scale channel rehabilitation proposed in the Lower Yuba River Actions, would be additional and complementary to the gravel augmentation program required of the Corps by NMFS' biological opinion, and would ideally be completed first to allow for an expansive increase in suitable spawning habitat. Once the Lower Yuba River Actions are completed, the long-term gravel augmentation program required of the Corps under NMFS' biological opinion would provide for long-term maintenance of the habitat created by the Lower Yuba River Actions.

## Battle Creek, Big Chico Creek, and Antelope Creek Habitat Expansion Actions

The Licensees identified another group of actions that, when combined, also would meet the goals, terms, and conditions of the HEA. This group of actions consists of habitat expansion and enhancement actions in three watersheds: Battle Creek, Big Chico Creek, and Antelope Creek and is referred to in this document as the Battle Creek, Big Chico Creek, and Antelope Creek Habitat Expansion Actions (Three-Creek Actions). The individual actions that make up the Three-Creek Actions consist of the following:

- Battle Creek Habitat Expansion Actions, provide partial funding for implementation of Phase 2 of the Battle Creek Salmon and Steelhead Restoration Project;
- Antelope Creek Habitat Expansion Action, construct a bridge at Paynes Crossing on Antelope Creek; and
- Big Chico Creek Habitat Expansion Action, rehabilitate the Iron Canyon Fish Ladder on Big Chico Creek.

The Three-Creek Actions are estimated to provide a net increase in habitat to support approximately 2,250 adult spring-run Chinook salmon, in addition to providing ancillary benefits to steelhead. The Three-Creek Actions have the potential to provide habitat expansion and enhancement in a more immediate and certain timeframe than the Lower Yuba River Actions, as each of the individual actions need only funding to begin implementation. For all three actions, feasibility and design studies are complete, permitting phases are imminent, underway, or complete, and implementation partners are established. The three actions are essentially "shovel-ready." As such, they have received extensive vetting and have support from a broad coalition of governmental, non-

governmental, public, and private stakeholders in their respective watersheds. Once constructed, operations and maintenance could be performed by implementation partners already identified and, in the case of the actions on Battle Creek and Big Chico Creek, using separate funds already committed by PG&E and DFG, respectively. These actions leverage existing efforts and funds expended by others, and have the potential to provide additional habitat sooner than the Lower Yuba River Actions.

Table ES-2 summarizes the attributes assigned to the Three-Creek Actions by the Licensees, as well as an evaluation of these actions applying the NMFS Approval Criteria specified in the HEA.

**Table ES-2.** Application of NMFS Approval Criteria to Battle Creek, Big Chico Creek, and Antelope Creek Habitat Expansion Actions (Three-Creek Actions)

| Action Attributes | Three-Creek Actions |
|---|---|
| Estimated contribution to Habitat Expansion Threshold | ~2,250 adult spring-run Chinook salmon[a, b] |
| Estimated cost | $20.6 million[c] |
| **NMFS Approval Criteria Evaluation[d]** | |
| Assures necessary testing, operations and maintenance? | Yes |
| Supports establishing geographically separate self-sustaining population?[e] | Yes |
| Supports segregating spring-run from fall-run?[e] | Yes |
| Eligible? | Yes |
| Expected to be implemented in a reasonable period of time? | Yes |

Note: Battle Creek, Big Chico Creek, and Antelope Creek Habitat Expansion Actions (Three-Creek Actions) consist of partial funding for implementation of Phase 2 of the Battle Creek Salmon and Steelhead Restoration Project, construction of a bridge at Paynes Crossing on Antelope Creek, and rehabilitation of the Iron Canyon fish ladder on Big Chico Creek

[a] Values reflect the number of adult fish supported by habitat expansion. The estimated contribution of an action to the Habitat Expansion Threshold (HET) represents an index of the increase in quality and quantity of habitat for spring-run Chinook salmon. Actual results of the actions could differ due to a variety of factors.

[b] Additional funding partners would need to be identified in order to meet this estimated contribution to the HET.

[c] Cost estimate includes partial funding for implementation of Phase 2 of the Battle Creek Salmon and Steelhead Restoration Project, and full funding for construction of Antelope and Big Chico Creek actions, as well as provisions for operations and maintenance not already committed to by others.

[d] Evaluation applies to the group of three actions, not necessarily each of the individual actions.

[e] Criterion not required for NMFS approval.

## Eligibility

The Battle Creek Restoration Project is a cooperative effort by the signatories of a 1999 Memorandum of Understanding (MOU). As stated in Section 1.4 of the MOU, it is a voluntary partnership between state and federal agencies, including NMFS, third-party donors, and PG&E. Currently, FERC has issued an Order to Construct Phase 1A of the Battle Creek Restoration Project and funding has been secured. Submittal of a license amendment application is imminent for Phase 1B and funding has been secured for this phase through the American Recovery and Reinvestment Act of 2009. A license amendment application has not been submitted for Phase 2 of the Battle Creek Restoration Project because full funding has not been secured for this phase. Section 16.0 of the MOU provides for its termination in a number of ways, including lack of funding sources. Phase 2 of the Battle Creek Restoration Project will not be implemented until full funding is secured. At this time, approximately $12 million of the estimated $47 million cost of Phase 2 has been identified but has not been secured.

NMFS issued a biological opinion on the *Long-Term Central Valley Project and State Water Project Operation, Criteria, and Plan* (OCAP) on June 4, 2009. The OCAP biological opinion states the following action to be taken with regard to Battle Creek:

> ***Action I.2.6****. Restore Battle Creek for Winter-Run, Spring-Run, and CV Steelhead*
>
> ***Objective:*** *To partially compensate for unavoidable adverse effects of project operations by restoring winter-run and spring-run to the Battle Creek watershed. A second population of winter-run would reduce the risk of extinction of the species from lost resiliency and increased vulnerability to catastrophic events.*
>
> ***Description of Action:*** *Reclamation shall direct discretionary funds to implement the Battle Creek Salmon and Steelhead Restoration Project. Phase 1A funding is currently allocated through various partners and scheduled to commence in Summer 2009 (Reclamation 2008c). DWR shall direct discretionary funds for Phase 1B and Phase 2, consistent with the proposed amended Delta Fish Agreement by December 31 of each year, Reclamation and DWR will submit a written report to NMFS on the status of the project, including phases completed, funds expended, effectiveness of project actions, additional actions planned (including a schedule for further actions), and additional funds needed. The Battle Creek Salmon and Steelhead Restoration Project shall be completed no later than 2019.*

As stated, the NMFS OCAP biological opinion Action I.2.6 requires the U.S. Bureau of Reclamation and DWR to direct discretionary funds to the Battle Creek Restoration Project. However, this statement does not ensure that such discretionary funds will be available, does not provide an alternate funding mechanism in the absence of such funds, as is presently the case, and ultimately does not secure full funding for Phase 2. The biological opinion also does not provide a means for completing the project before 2019.

Prior to submitting a final HEP, the Licensees will consult with the signatories of the Battle Creek Restoration Project MOU concerning additional partners for full funding of Phase 2. After the remaining funds needed to complete Phase 2 have been secured, the Licensees would provide up to a $16.9 million contribution pursuant to the cost sharing provisions agreed to by DWR and PG&E for implementation of the HEA. Consistent with those provisions, PG&E will be the performing party for construction of capital improvements associated with the $16.9 million contribution. In order to provide consistency and continuity in construction of capital improvements for all of Phase 2, the Licensees favor PG&E's role as the performing party for construction of all Phase 2 capital improvements.

# Summary of Recommended Actions

In summary, the Licensees believe that each group of recommended actions in this draft HEP meets the goals, terms, and conditions of the HEA; and support the inclusion of either group of actions in the final HEP.

# Outreach

Stakeholder input and public support are critical to successful implementation of the actions proposed under the HEP. Throughout development of this draft HEP, the Licensees have worked closely with the signatories to the HEA and sought input from local Resource Conservation Districts and watershed groups to identify potential actions that could qualify under the HEA. Chapter 2 details the various outreach activities conducted over the past 2 years. The Licensees plan to continue outreach efforts until a final HEP is approved for implementation and then work with the appropriate stakeholders to ensure the success of the HEP.

# Contents


**Page**

List of Appendices ..... vi
Tables ..... vii
Figures ..... ix
Acronyms and Abbreviations ..... xi
Acknowledgments ..... xiii

**Chapter 1 Introduction ..... 1-1**
1.1 Background of the HEA ..... 1-2
1.1.1 FERC Relicensing for Feather River Projects ..... 1-2
1.1.2 HEA Negotiated as an Alternative to Prescribed Fish Passage ..... 1-3
1.2 Goal of the HEA ..... 1-3
1.3 Potential Habitat Expansion Actions ..... 1-4
1.4 Timeline ..... 1-4

**Chapter 2 Outreach Activities ..... 2-1**
2.1 HEA Website ..... 2-1
2.2 Outreach to Signatories to the HEA ..... 2-2
2.2.1 Consultation with NMFS ..... 2-2
2.2.2 Letter to HEA Signatories ..... 2-3
2.2.3 Meetings with HEA Signatories ..... 2-4
2.3 Outreach to Other Stakeholders ..... 2-4
2.3.1 Salmonid Restoration Federation's Spring-Run Chinook Salmon Symposium ..... 2-5
2.3.2 Agency Partnering Meeting ..... 2-5
2.3.3 Lower Yuba River Symposium ..... 2-5
2.3.4 Combined Meetings with HEA Signatories and Other Stakeholders ..... 2-5
2.3.5 Communication on Specific Habitat Expansion Actions ..... 2-6
2.3.6 Coordination with Landowners ..... 2-6

**Chapter 3 Application of HEA Criteria ..... 3-1**
3.1 HEA Criteria and Criteria Definitions ..... 3-1
3.1.1 Evaluation Criteria ..... 3-2
3.1.2 Selection Criteria ..... 3-3
3.1.3 Approval Criteria ..... 3-3
3.2 Applying the HEA Criteria ..... 3-4
3.2.1 Developing Habitat Expansion Actions ..... 3-4
3.2.2 Applying Evaluation Criteria ..... 3-8

3.2.3 Applying Selection Criteria ..... 3-11

**Chapter 4 Contribution to the HET ..... 4-1**
4.1 HEA Conceptual Framework ..... 4-1
4.1.1 Habitat Potential ..... 4-2
4.1.1 Relationship of HEA Actions to the Viable Salmonid Population Concept ..... 4-4
4.2 Procedure for Determining Contribution to the HET ..... 4-7
4.2.1 General Concept of the HET Contribution Procedure ..... 4-7
4.2.2 Biological Assumptions ..... 4-9
4.2.3 Watershed Diagnosis ..... 4-11
4.2.4 Watershed Treatment ..... 4-14
4.2.5 Results ..... 4-18
4.3 References ..... 4-19

**Chapter 5 Recommended Actions ..... 5-1**
5.1 Lower Yuba River Habitat Expansion Actions ..... 5-1
5.1.1 Nexus to Species Recovery Plans ..... 5-3
5.1.2 Springboard to Upper Yuba River ..... 5-4
5.1.3 Stakeholder Support ..... 5-4
5.1.4 Eligibility ..... 5-5
5.1.5 Options to Segregation Weir ..... 5-6
5.1.6 Summary of Recommendation for Lower Yuba River Actions ..... 5-7
5.2 Battle Creek, Big Chico Creek, and Antelope Creek Habitat Expansion Actions ..... 5-8
5.2.1 Battle Creek Habitat Expansion Actions ..... 5-9
5.2.2 Big Chico Creek and Antelope Creek Actions ..... 5-13
5.2.1 Summary of Recommendation for Three-Creek Actions ..... 5-13
5.3 Reference ..... 5-13

**Chapter 6 Lower Yuba River Habitat Expansion Actions ..... 6-1**
6.1 Description of Habitat Expansion Actions ..... 6-1
6.1.1 Background ..... 6-1
6.1.2 Location ..... 6-2
6.1.3 Purpose ..... 6-2
6.1.4 Recommended Actions ..... 6-3
6.1.5 Sources ..... 6-3
6.2 Context for Action ..... 6-4
6.2.1 Description of the Watershed ..... 6-4
6.2.2 Status of Spring-Run Chinook Salmon and Steelhead Runs ..... 6-5
6.2.3 Limiting Factors ..... 6-6
6.3 Contribution to the HET ..... 6-9
6.4 Spawning Habitat Rehabilitation ..... 6-10
6.4.1 Description ..... 6-10
6.4.2 Objectives and Benefits ..... 6-12
6.4.3 Contribution to the HET ..... 6-13
6.4.4 Estimated Cost ..... 6-13

6.4.5 Implementation Schedule ....6-14
6.4.6 Implementation Responsibilities of Licensees ....6-14
6.4.7 Rationale for Selection ....6-15
6.4.8 Other Issues ....6-16
6.5 Segregation Weir ....6-17
6.5.1 Description ....6-17
6.5.2 Objectives and Benefits ....6-18
6.5.3 Contribution to the HET ....6-19
6.5.4 Estimated Cost ....6-20
6.5.5 Implementation Schedule ....6-20
6.5.6 Implementation Responsibilities of Licensees ....6-20
6.5.7 Rationale for Selection ....6-21
6.5.8 Other Issues ....6-21
6.6 Juvenile Rearing Habitat Restoration ....6-22
6.6.1 Description ....6-22
6.6.2 Objectives and Benefits ....6-29
6.6.3 Contribution to the HET ....6-29
6.6.4 Estimated Cost ....6-29
6.6.5 Implementation Schedule ....6-30
6.6.6 Implementation Responsibilities of Licensees ....6-30
6.6.7 Rationale for Selection ....6-31
6.6.8 Other Issues ....6-31
6.7 References ....6-31
6.7.1 Printed References ....6-31
6.7.2 Personal Communications ....6-33

**Chapter 7 Antelope Creek Habitat Expansion Action ....7-1**
7.1 Description of Habitat Expansion Action ....7-1
7.1.1 Background ....7-1
7.1.2 Location ....7-1
7.1.3 Purpose ....7-2
7.1.4 Recommended Action ....7-2
7.1.5 Sources ....7-2
7.2 Context for Action ....7-2
7.2.1 Description of the Watershed ....7-2
7.2.2 Status of Spring-Run Chinook Salmon and Steelhead Runs ....7-3
7.2.3 Limiting Factors ....7-3
7.3 Paynes Crossing Bridge Construction ....7-4
7.3.1 Description ....7-4
7.3.2 Objectives and Benefits ....7-4
7.3.3 Contribution to the HET ....7-4
7.3.4 Estimated Cost ....7-5
7.3.5 Implementation Schedule ....7-5
7.3.6 Implementation Responsibilities of Licensees ....7-5
7.3.7 Rationale for Selection ....7-6
7.3.8 Other Issues ....7-7
7.4 References ....7-7
7.4.1 Printed References ....7-7
7.4.2 Personal Communications ....7-8

**Chapter 8 Big Chico Creek Habitat Expansion Action ..... 8-1**
8.1 Description of Habitat Expansion Actions ..... 8-1
8.1.1 Background ..... 8-1
8.1.2 Location ..... 8-1
8.1.3 Purpose ..... 8-2
8.1.4 Recommended Action ..... 8-2
8.1.5 Sources ..... 8-2
8.2 Context for Action ..... 8-2
8.2.1 Description of the Watershed ..... 8-2
8.2.2 Status of Spring-Run Chinook Salmon and Steelhead Runs ..... 8-3
8.2.3 Limiting Factors ..... 8-3
8.3 Iron Canyon Fish Ladder Rehabilitation ..... 8-4
8.3.1 Description ..... 8-4
8.3.2 Objectives and Benefits ..... 8-4
8.3.3 Contribution to the HET ..... 8-4
8.3.4 Estimated Cost ..... 8-5
8.3.5 Implementation Schedule ..... 8-5
8.3.6 Implementation Responsibilities of Licensees ..... 8-5
8.3.7 Rationale for Selection ..... 8-6
8.3.8 Other Issues ..... 8-7
8.4 References ..... 8-7
8.4.1 Printed References ..... 8-7
8.4.2 Personal Communications ..... 8-8

**Chapter 9 Battle Creek Habitat Expansion Actions ..... 9-1**
9.1 Description of Habitat Expansion Actions ..... 9-1
9.1.1 Background ..... 9-1
9.1.2 Location ..... 9-2
9.1.3 Purpose ..... 9-2
9.1.4 Recommended Actions ..... 9-3
9.1.5 Sources ..... 9-3
9.2 Context for Action ..... 9-3
9.2.1 Description of the Watershed ..... 9-3
9.2.2 Status of Spring-Run Chinook Salmon and Steelhead Runs ..... 9-4
9.2.3 Limiting Factors ..... 9-5
9.3 Battle Creek Habitat Expansion Actions ..... 9-5
9.3.1 Description ..... 9-5
9.3.2 Objectives and Benefits ..... 9-8
9.3.3 Contribution to the HET ..... 9-9
9.3.4 Estimated Cost ..... 9-10
9.3.5 Implementation Schedule ..... 9-11
9.3.6 Implementation Responsibilities of Licensees ..... 9-11
9.3.7 Rationale for Selection ..... 9-12
9.3.8 Other Issues ..... 9-13
9.4 References ..... 9-15
9.4.1 Printed References ..... 9-15
9.4.2 Personal Communications ..... 9-16

**Chapter 10 Remaining Phases of the HEA .....10-1**
10.1 Outreach .....10-1
10.2 Final HEP .....10-2
10.2.1 Contents of the Final HEP .....10-3
10.2.2 Pre-Approval Consultation .....10-3
10.2.3 NMFS Approval Criteria .....10-3
10.2.4 Determination of Contribution to the HET .....10-4
10.2.5 Approval Decision by NMFS .....10-5
10.3 Preliminary Design Phase .....10-5
10.3.1 Feasibility-Level Designs and Cost Estimates .....10-5
10.3.2 Semi-Annual Status Reports .....10-6
10.3.3 Preliminary Design Report .....10-6
10.3.4 Consistency Determination by NMFS .....10-6
10.3.5 FERC Licensing .....10-7
10.4 Final Design and Permitting Phase .....10-7
10.4.1 Bid-Level Designs, Cost Estimates, and Related Permitting .....10-7
10.4.2 Semi-Annual Status Reports .....10-7
10.4.3 Final Design and Permitting Report .....10-8
10.4.4 Consistency Determination by NMFS .....10-8
10.5 Implementation Phase .....10-8
10.5.1 Implementation of Approved Action(s) .....10-9
10.5.2 Semi-Annual Status Reports .....10-9
10.5.3 Final Report .....10-9
10.6 Final Test Phase .....10-9
10.6.1 Start-Up Testing .....10-10
10.6.2 Semi-Annual Status Reports .....10-10
10.6.3 Final Test Report .....10-10
10.6.4 Functionality Determination by NMFS .....10-10

# Appendices


A Approval and Implementation Schedule for Habitat Expansion Actions

B Working Definitions of Evaluation, Selection, and Approval Criteria

C Habitat Expansion Actions
- C1 Draft Working List of Potential Actions
- C2 Working List of Potential Actions
- C3 Short List of Potential Actions
- C4 Ranked Preliminary List of Viable Actions with Evaluation Criteria Scoring
- C5 Ranked List of Viable Actions with Selection Criteria Scoring

D Central Valley Spring-run Chinook Salmon and Steelhead in the Sacramento River Basin Background Report

E Action-Specific Calculations of Contribution to the Habitat Expansion Threshold

F Questionnaires for Recommended Actions
- F1 Questionnaires received on the Lower Yuba River Actions
- F2 Questionnaire received on the Antelope Creek Action
- F3 Questionnaires received on the Big Chico Creek Action
- F4 Questionnaire received on the Battle Creek Actions

G Habitat Expansion For Spring-Run Chinook Salmon and Steelhead in the Lower Yuba River – Prepared for the HEA Steering Committee by members of the Yuba Accord River Management Team

# Tables

**Page**


4-1. Spatial Structure of the Central Valley Spring-Run Chinook Salmon Evolutionary Significant Unit....4-6

4-2. Definitions of Environmental Attributes That Are Potentially Limiting Factors for Spring-Run Chinook Salmon....4-10

4-3. Adopted Ranking of Importance of Environmental Attributes in Determining Productivity and Capacity of Spring-Run Chinook Salmon in Two Stream Size Categories. ....4-10

4-4. Example of Environmental Rating Scores for a Sample Stream ....4-12

4-5. Weighted and Normalized Habitat Change Scores for Chinook Spring-Run Salmon ....4-13

4-6. Allocation of Recovery Potential Based on the Species-Interpreted Habitat Change Scores (Numbers of Adult Chinook Spring-Run Salmon) ....4-14

4-7. Adopted Potential of Action Types to Affect Environmental Conditions....4-15

4-8. Example of Action Intensity for Three Hypothetical Proposed Actions and Their Relationship to Action Types....4-16

4-9. Expectation of Change in Attributes for Three Hypothetical Proposed Actions....4-17

4-10. Estimated Contribution to the Habitat Expansion Threshold of Hypothetical Combined Actions (Adult Spring-Run Chinook Salmon) ....4-19

5-1. Application of NMFS Approval Criteria to Lower Yuba River Habitat Expansion Actions (Lower Yuba River Actions) ..... 5-3

5-2. Application of NMFS Approval Criteria to Antelope Creek and Big Chico Creek Habitat Expansion Actions ..... 5-7

5-3. Application of NMFS Approval Criteria to Battle Creek, Big Chico Creek, and Antelope Creek Habitat Expansion Actions (Three-Creek Actions) ..... 5-9

5-4. Application of NMFS Approval Criteria to the Battle Creek Habitat Expansion Actions ..... 5-12

6-1 Contribution of Actions in the Lower Yuba River to the Habitat Expansion Threshold ..... 6-10

# Figures

**Page**


4-1 HEA Conceptual Framework for Evaluating the Contribution of Actions to the Habitat Expansion Threshold .....4-3

4-2 Adaptation of HEA Conceptual Framework to Determining the Contribution to the Habitat Expansion Threshold .....4-8

4-3 Comparison of Raw and Biologically Interpreted Habitat Rating Scores for an Example Stream .....4-13

5-1 Targeted Watersheds for Habitat Expansion Actions Battle Creek, Antelope Creek, Big Chico Creek, and Yuba River .....follows 5-2

6-1 Lower Yuba River Habitat Expansion Actions .....follows 6-2

6-2 Yuba River Shot Rock Deposits .....follows 6-12

6-3 Juvenile Rearing Habitat Restoration Sites in the Lower Yuba River.....follows 6-24

6-4. Upper Guilt Edge Bar Site for Juvenile Rearing Habitat Restoration .....6-25

6-5. First Island Site for Juvenile Rearing Habitat Restoration .....6-25

6-6. North Silica Bar and Silica Bar Sites for Juvenile Rearing Habitat Restoration.....6-26

6-7. Hammon Bar Site for Juvenile Rearing Habitat Restoration.....6-26

6-8. South Bar above Daguerre Point Dam Site for Juvenile Rearing Habitat Restoration .....6-27

6-9. Waterway 13 Site for Juvenile Rearing Habitat Restoration.....6-27

6-10. Narrow Bar Site for Juvenile Rearing Habitat Restoration.....6-28

6-11. Goldfields Terminus Bar Site for Juvenile Rearing Habitat Restoration .....6-28

7-1 Antelope Creek Action – Paynes Crossing.....follows 7-2

8-1 Big Chico Creek Action – Iron Canyon Fish Ladder .....follows 8-2

9-1 Battle Creek Habitat Expansion Actions.....follows 9-2

# Acronyms and Abbreviations

| | |
|---|---|
| AFRP | Anadromous Fish Restoration Program |
| Antelope Creek Action | Antelope Creek Habitat Expansion Action |
| Background Report | Background Report on the Status of Spring-Run Chinook Salmon and Central Valley Steelhead in the Sacramento River Basin |
| Battle Creek Actions | Battle Creek Habitat Expansion Actions |
| Battle Creek Restoration Project | Battle Creek Salmon and Steelhead Restoration Project |
| BCCWA | Big Chico Creek Watershed Alliance |
| Big Chico Creek Action | Big Chico Creek Habitat Expansion Actions |
| CalTrout | California Trout, Inc. |
| CNFH | Coleman National Fish Hatchery |
| Corps | U.S. Army Corps of Engineers |
| CSU | Chico State University |
| DEMs | Digital Elevation Models |
| DFG | California Department of Fish and Game |
| DWR | California Department of Water Resources |
| ESA | Endangered Species Act |
| ESU | evolutionarily significant unit |
| FERC | Federal Energy Regulatory Commission |
| FPA | Federal Power Act |
| FPC | Federal Power Commission |
| GIS | geographic information system |
| HEA | Habitat Expansion Agreement for Central Valley Spring-Run Chinook Salmon and California Central Valley Steelhead |
| HEP | Habitat Expansion Plan |
| HET | Habitat Expansion Threshold |
| Lower Yuba River Actions | Lower Yuba River Habitat Expansion Actions |
| MAF | million acre-feet |

| | |
|---|---|
| MOU | Memorandum of Understanding |
| NMFS | National Marine Fisheries Service |
| NMFS Draft Recovery Plan | NMFS Draft Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-Run Chinook Salmon and Central Valley Spring-Run Chinook Salmon and the Distinct Population Segment of Central Valley Steelhead |
| NOAA Fisheries | National Oceanic and Atmospheric Administration National Marine Fisheries Service |
| O&M | operations and maintenance |
| OCAP | Operation, Criteria, and Plan |
| PG&E | Pacific Gas and Electric Company |
| Poe | Poe Hydroelectric Project No. 2107 |
| Public Draft Recovery Plan | Public Draft Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-Run Chinook Salmon and Central Valley Spring-Run Chinook Salmon and the Distinct Population Segment of Central Valley Steelhead |
| RCDs | Resource Conservation Districts |
| Reclamation | U.S. Department of the Interior, Bureau of Reclamation |
| Restoration Project | Battle Creek Salmon and Steelhead Restoration Project |
| RM | river mile |
| RMT | River Management Team |
| SYRCL | South Yuba River Citizens League |
| USFWS | U.S. Fish and Wildlife Service |
| VSP | viable salmonid populations |
| YCWA | Yuba County Water Agency |

# Acknowledgments

The Licensees are pleased to present this draft Habitat Expansion Plan (HEP) for comment by the HEA signatories and other stakeholders. The Licensees are committed to responding to the comments and to the ultimate success of the HEA.

Throughout this document, reference is made to the Steering Committee as defined by the HEA Coordination Agreement between the Licensees party to the HEA, the California Department of Water Resources (DWR) and Pacific Gas and Electric Company (PG&E). The Steering Committee consists of two representatives each from DWR and PG&E. The Steering Committee members are:

- Heidi Rooks, Branch Chief, Department of Water Resources, Division of Environmental Services
- Liv K. Imset, Senior License Coordinator, Pacific Gas and Electric Company, Power Generation
- Chris Wilkinson, Senior Environmental Scientist, Habitat Restoration Section, Department of Water Resources, Division of Environmental Services
- Paul Kubicek, Senior Consulting Scientist – Aquatic Biologist, Pacific Gas and Electric Company, Land and Environmental Management

For the purposes of the HEA, the Steering Committee represents the views of the Licensees.

The Steering Committee would like to express its appreciation to all those who assisted in implementing the HEA and developing this draft HEP. The Steering Committee solicited and received input from many additional DWR and PG&E employees during the process. Their input was critical to the success of this effort.

The Steering Committee also retained a consultant, ICF Jones & Stokes, to aid in the implementation activities and development of the draft HEP. Key members of the ICF team included:

- Colleen Lingappaiah, Project Manager, Water Resources, ICF Jones & Stokes
- Joan Lynn, Technical Editor, Egret, Inc. for ICF Jones & Stokes

- Chip McConnaha, Senior Fisheries Ecologist, ICF Jones & Stokes

These individuals participated in most of the Steering Committee meetings and were instrumental in completing the draft HEP. They also received input and support from many of their employees.

The Steering Committee also formed a Technical Team of professional biologists including the following individuals:

- Paul Kubicek
- Chris Wilkinson
- Chip McConnaha
- Erin Chappell, Environmental Scientist, Habitat Restoration Section, Department of Water Resources, Division of Environmental Services
- Steve Brumbaugh, Environmental Scientist, Habitat Restoration Section, Department of Water Resources, Division of Environmental Services

The Steering Committee Technical Team, referred to throughout this document, carried out the collection of potential actions to be considered, application of the HEA criteria, and development and application of the HET contribution procedure. The Technical Team also participated in most of the Steering Committee meetings and consulted with representatives of the signatories, stakeholder groups, and other technical professionals as available throughout the process.

The Steering Committee would like to express its appreciation to the signatories, stakeholder groups, and other technical professionals who provided critical input used during the HEA process and development of the draft HEP. Individuals from many organizations stepped forward to participate in the HEA process and responded to requests for information.

Lastly, the Steering Committee would like to thank the employees of the Fairfield-Suisun Sewer District who provided both hospitality and regular meeting space for the past 2 years.

# Chapter 1
# Introduction

Effective November 20, 2007, Pacific Gas and Electric Company (PG&E) and the California Department of Water Resources (DWR) entered into the *Habitat Expansion Agreement for Central Valley Spring-Run Chinook Salmon and California Central Valley Steelhead* (HEA) with the following parties: American Rivers, Arthur G. Baggett, Jr.[1]; California Department of Fish and Game (DFG); U.S. Department of Agriculture Forest Service; National Marine Fisheries Service (NMFS); U.S. Fish and Wildlife Service (USFWS); and State Water Contractors, Inc. A copy of the HEA is available on the HEA website: http://www.sac-basin-hea.com/default.aspx. DWR and PG&E (the Licensees) formed a Steering Committee, comprised of two representatives each, to execute the HEA in accordance with its terms and conditions.

The HEA allows DWR and PG&E 2 years to jointly identify, evaluate, and select the most promising and cost-effective action(s) to expand spawning, rearing, and adult holding habitat for spring-run Chinook salmon and steelhead in the Sacramento River Basin. These actions are proposed as an alternative to NMFS exercising its Section 18 authority under the Federal Power Act (FPA) to require trap-and-haul fish passage over Oroville Dam in the new Federal Energy Regulatory Commission (FERC) licenses for DWR's Oroville Facilities Project and PG&E's Upper North Fork Feather River Hydroelectric Project and Poe Hydroelectric Project (all of which are located in the Feather River system). This draft Habitat Expansion Plan (HEP) describes how the HEA has been carried out to date; presents the recommended actions; and describes each action in detail, including its estimated contribution to the Habitat Expansion Threshold (HET), a prefeasibility cost estimate, a proposed implementation schedule, the implementation responsibilities of each Licensee, and the rationale for selecting the action. This HEP also describes outreach activities that the Licensees have taken to keep the HEA signatories and directly affected and responsive third parties (herein referred to as *other stakeholders*) informed about the HEA process. Finally, this HEP also explains the remaining phases associated with the HEA.

[1] Mr. Baggett signed the HEA as a recommendation to the California State Water Resources Control Board (State Water Board), not as a Party to the HEA. Mr. Baggett will not be participating in the State Water Board's consideration of any petition for water quality certification for any Habitat Expansion Plan pursuant to Section 401 of the federal Clean Water Act.

# 1.1 Background of the HEA

## 1.1.1 FERC Relicensing for Feather River Projects

DWR constructed and operates the Oroville Facilities, FERC Project No. 2100 (Oroville), on the lower Feather River. Oroville was developed as part of the California State Water Project, a water storage and delivery system of reservoirs, aqueducts, power plants, and pumping plants. The State Water Project makes deliveries of supplemental water to two-thirds of California's population and over 750,000 acres of agricultural lands. Oroville is also operated to provide power generation, improve water quality in the Sacramento and San Joaquin Delta, manage Feather River floodwaters, provide recreation, and enhance habitat for fish and wildlife.

Oroville operates under a license originally issued by the Federal Power Commission (FPC) on February 11, 1957, for a term of 50 years. That license expired on January 31, 2007; however, the Project has been operated since then under annual licenses pursuant to Section 15 of the FPA. Under the requirements of the FPA and FERC regulations, DWR filed a timely application for a new license on January 26, 2005. The application is currently pending before FERC.

PG&E owns and operates the Poe Hydroelectric Project, FERC Project No. 2107 (Poe), on the North Fork Feather River under a license issued by the FPC on October 26, 1953, for a term of 50 years. Under the requirements of the FPA and FERC regulations, PG&E filed an application for a new license for Poe on October 2, 2001. This application is currently pending before FERC. The original license for Poe expired on September 30, 2003; since that time, the project has been operating under annual licenses pursuant to Section 15 of the FPA.

PG&E owns and operates the Upper North Fork Feather River Hydroelectric Project, FERC Project No. 2105 (Upper North Fork Feather River), under a license issued by the FPC on January 24, 1955, for a term of 50 years. Under the requirements of the FPA and FERC regulations, PG&E filed an application for a new license for the Upper North Fork Feather River on October 23, 2002, which is currently pending before FERC. The original license for the Upper North Fork Feather River expired on October 31, 2004; since that time, the project has been operating under annual licenses pursuant to Section 15 of the FPA.

PG&E also owns and operates a third project on the North Fork Feather River, the Rock Creek-Cresta Hydroelectric Project, FERC Project No. 1962 (Rock Creek-Cresta), under a license issued by FERC on October 24, 2001, which expires on September 30, 2034.

### 1.1.2 HEA Negotiated as an Alternative to Prescribed Fish Passage

Section 18 of the FPA gives NMFS the authority to require fishways or fish passage which they exercised in the FERC relicensing proceedings for the Oroville and Upper North Fork Feather River Projects for DWR and PG&E, respectively. NMFS stated that a trap-and-haul program for spring-run Chinook salmon in the Feather River system would meet its fish passage objectives. The trap-and-haul program would involve trapping adult fish below the Oroville Dam, hauling them upstream, and placing them in the upper North Fork Feather River. The program also would require collecting downstream migrants in the upper North Fork Feather River and hauling them back downstream below Oroville Dam. NMFS prescribed the upper end of the trap-and-haul program in the Upper North Fork Feather River relicensing proceeding and intended to prescribe the lower end of the trap-and-haul program in the Oroville relicensing proceeding.

The trap-and-haul program generated concern because of its high estimated cost and the potentially low likelihood for success. Ultimately, DWR and PG&E, together with other participants in the relicensing proceedings, came together to discuss alternatives to trap-and-haul for expanding anadromous fish habitat. The parties negotiated the HEA to establish an approach for identifying, evaluating, selecting, and implementing the most promising and cost-effective action(s) to expand spawning, rearing, and adult holding habitat in the Sacramento River Basin in lieu of the resource agencies or other parties seeking fish passage on the Feather River or its tributaries in the relicensing of the Oroville, Poe, and Upper North Fork Feather River Projects, or through amendment of the license for the Rock Creek-Cresta Project. As stated in Section 1.2 of the HEA, “Purpose of Agreement,” the HEA will fully mitigate for impacts of all fish species due to the blockage of fish passage caused by the Feather River Hydroelectric Projects; and resolve among the parties to the HEA, during the term of the HEA, issues related to regulatory conditions for fish passage associated with or related to any of the Feather River Hydroelectric Projects in excess of the actions contemplated under the HEA.

## 1.2 Goal of the HEA

The overall goal of the HEA (Section 2.1 of the HEA, “Goal of Agreement”) is to expand habitat with the physical characteristics necessary to support spawning, rearing, and adult holding of spring-run Chinook salmon and steelhead in the Sacramento River Basin as a contribution to the conservation and recovery of these species. Habitat expansion is to be accomplished through enhancements to existing accessible habitat, improving access to habitat, or other action(s) and is intended to fully mitigate for any presently unmitigated impacts due to the blockage of passage of all fish species caused by the Feather River Hydroelectric Projects.

The specific goal of the HEA (Section 2.2 of the HEA, "Habitat Expansion Threshold") is to expand spawning, rearing, and adult holding habitat sufficiently to accommodate an estimated net increase of 2,000 to 3,000 spring-run Chinook salmon for spawning in the Sacramento River Basin, as compared to the habitat available under any relevant existing requirements or commitments (i.e., actions expected to occur in a timeframe comparable to implementation of habitat expansion action[s] under the HEA). The HET is focused on spring-run Chinook salmon as the priority species, as expansion of habitat for spring-run typically accommodates steelhead as well.

# 1.3 Potential Habitat Expansion Actions

Section 3.1 of the HEA, "Scope of Eligible Habitat Expansion Actions," states that habitat expansion actions may include, among other things:

- dam removals or dam re-operation,
- creation or enhancement of fishways,
- water temperature or flow improvements, and
- other physical habitat enhancements.

The Licensees identified, evaluated, and recommended potential habitat expansion actions using criteria identified in the HEA, including:

- seventeen non-prioritized Evaluation Criteria (Section 4.1.1 of the HEA) to screen potential habitat expansion actions and develop a preliminary list of viable actions, and
- four non-prioritized Selection Criteria (Section 4.1.2 of the HEA) to select recommended habitat expansion actions for implementation.

The approach taken by the Licensees to apply the Evaluation and Selection Criteria to the potential habitat expansion actions and select the recommended actions is described in Chapter 3.

NMFS will consider six Approval Criteria (Section 4.2.3 of the HEA), along with comments from the HEA signatories and other stakeholders, and any other relevant information, when deciding whether to approve the recommendations made by the Licensees.

# 1.4 Timeline

This draft HEP is being submitted to NMFS, as well as to the HEA signatories and other stakeholders, for a 90-day review and comment period. Within 90 days after the close of this review and comment period, or by May 20, 2010, the Licensees will then have 90 days to submit a final HEP for approval by NMFS. The Licensees and NMFS may extend the time periods by mutual agreement to accommodate the approval process. (Section 4.2 of the HEA).

The proposed approval and implementation schedule for the habitat expansion actions recommended by the Licensees is presented in Appendix A. The remaining phases associated with implementing the HEA are described further in Chapter 10.

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Chapter 2
# Outreach Activities

Stakeholder input and public support are critical to successful implementation of the actions proposed under the HEP. Throughout development of this draft HEP, the Licensees have worked closely with the signatories to the HEA and sought input from local Resource Conservation Districts (RCDs) and watershed groups to identify potential actions that could qualify under the HEA. The following sections describe how the Licensees, using the Steering Committee, sought input and shared information with the signatories and other stakeholders in development of this draft HEP. The Licensees will continue its outreach efforts until a final HEP is approved for implementation.

## 2.1 HEA Website

The Steering Committee established a website early in the process to share information related to the HEA. The following documents are currently available on the website:

- the HEA;
- the first annual HEA status report;
- the draft Work Plan;
- Working Definitions of the HEA Evaluation, Selection, and Approval Criteria;
- the list of potential habitat expansion actions; and
- presentations from meetings with the HEA signatories and other stakeholders.

In addition, the website offered instructions and forms for the HEA signatories and other stakeholders to submit actions for consideration in the HEP. Specifically, a questionnaire was made available for the HEA signatories and other stakeholders to complete and submit potential habitat expansion actions to the Steering Committee for consideration under the HEA. The 22 questionnaires that were received by the Steering Committee are posted on the HEA website.

# 2.2 Outreach to Signatories to the HEA

The Licensees actively reached out to the signatories to the HEA directly and through various venues. Some of the outreach activities that the Licensees arranged or participated in are described below.

## 2.2.1 Consultation with NMFS

The Licensees scheduled meetings with NMFS periodically to discuss the HEA. Meetings included two conference calls with NMFS (on April 30, 2008, and May 28, 2009) and two face-to-face meetings with NMFS (on August 20, 2008, and April 8, 2009).

On April 30, 2008, the Licensees participated in a conference call with representatives from NMFS to:

- provide NMFS with an update on the Licensees's efforts on implementing the HEA;
- identify which branch from NMFS to work with regarding the NMFS Approval Criteria identified in the HEA;
- obtain feedback from NMFS on the idea of soliciting proposals as a means of identifying potential actions;
- receive feedback from NMFS on the compilation of appropriate actions from the PG&E/California Trout, Inc. (CalTrout) effort to prioritize Central Valley anadromous salmonid recovery actions (described below), and how this process could be integrated with the NMFS *Co-Manager Review Draft Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-Run Chinook Salmon and Central Valley Spring-Run Chinook Salmon and the Distinct Population Segment of Central Valley Steelhead* (Co-Manager Review Draft Recovery Plan); and
- obtain input on how the Licensees could integrate the HEA process with other recovery planning efforts, such as the USFWS Anadromous Fish Restoration Program (AFRP) and the CALFED Ecosystem Restoration Program.

On August 20, 2008, the Licensees met with NMFS and discussed the following topics:

- the Steering Committee's presentation at the July 10, 2008 Spring-Run Chinook Salmon Symposium sponsored by the Salmonid Restoration Federation;
- the draft Work Plan for fulfilling the HEA and efforts to date;
- application of the HEA criteria to the PG&E/CalTrout Prioritized Actions Contributing to Salmon and Steelhead Recovery Project list of prioritized actions;

- availability and use of the NMFS Co-Manager Review Draft Recovery Plan;
- methodologies for determining contribution of actions to the HET; and
- coordination with the HEA signatories.

On April 8, 2009, the Licensees met with NMFS to review:

- the framework for evaluating and selecting habitat expansion actions;
- Working Definitions of the Evaluation, Selection, and Approval Criteria;
- methodologies for determining contribution to the HET; and
- the list of potential habitat expansion actions.

On May 28, 2009, the Licensees held a conference call with NMFS to discuss the following topics:

- NMFS review and comments on HEA documents, including the HEP timeline; HEA conceptual framework; and *Working Definitions of the Evaluation, Selection, and Approval Criteria*;
- approach for applying the HEA Evaluation Criteria;
- Working List of Potential Actions; and
- recommendations for determining contribution to the HET.

The Licensees communicated with NMFS periodically through emails and informal phone calls to keep NMFS informed on progress toward fulfilling the HEA, and to seek guidance on various HEA-related issues and how those issues should be reflected in the draft HEP.

### 2.2.2 Letter to HEA Signatories

On October 28, 2008, the Steering Committee sent a letter to the HEA signatories, to provide them with an update on implementation of the HEA and to initiate contact with staff from the various HEA parties in order to obtain additional contacts for, and information on, potential habitat expansion actions.

### 2.2.3 Meetings with HEA Signatories

The Steering Committee first met with the signatories to the HEA in January 2009 to solicit information on potential habitat expansion actions, identify contact persons for additional follow-up on potential actions, facilitate the receipt of completed questionnaires (see discussion below), and obtain a common understanding of the HEA criteria. Three meetings, which were divided by watersheds within the Sacramento River Basin, took place on:

- January 14, 2009, in Chico, California, focusing on potential actions in the central Sacramento River Basin watersheds;
- January 21, 2009, in Red Bluff, California, focusing on potential actions in the northern Sacramento River Basin watersheds; and
- January 28, 2009, in Sacramento, California, focusing on potential actions in the southern Sacramento River Basin watersheds.

In particular, the Steering Committee requested that the HEA signatories provide input on the Draft Working List of Potential Habitat Expansion Actions. The signatories to the HEA were also asked to submit information on actions to be considered for the HEP by completing an HEA comment form or questionnaire.

## 2.3 Outreach to Other Stakeholders

The Steering Committee also contacted County Supervisors, local RCDs, and watershed groups in the Sacramento River Basin to obtain their input on potential habitat expansion actions to be considered in the draft HEP. The various ways that the Steering Committee reached out to other stakeholders are described below.

- On March 6, 2009, the Steering Committee sent a letter to stakeholders informing them about the opportunity for funding spring-run Chinook salmon and steelhead restoration actions and soliciting their feedback on the development of potential habitat expansion actions for the HEP;
- On March 10, 2009, the Steering Committee posted a new page on the HEA website providing stakeholders with instructions on how to provide input on potential habitat expansion actions by completing a questionnaire; and
- During April through September 2009, the Steering Committee contacted individual RCDs and watershed groups via personal communication, offering information on the HEA and informing the stakeholders on how to provide input on potential habitat actions.

The following sections describe other outreach efforts by the Steering Committee.

### 2.3.1 Salmonid Restoration Federation's Spring-Run Chinook Salmon Symposium

On July 10, 2008, the Steering Committee gave a presentation on the HEA and participated in a panel discussion on habitat expansion opportunities for spring-run Chinook salmon at the *Salmonid Restoration Federation's Spring-Run Chinook Salmon Symposium* held in Nevada City, California. The presentation is available on the HEA website.

### 2.3.2 Agency Partnering Meeting

On December 5, 2008, the Steering Committee attended the 16th Partnering Session of USFWS, NMFS, U.S. Army Corps of Engineers (Corps), U.S. Environmental Protection Agency, and DFG to make a presentation on the HEA. This meeting provided the opportunity to inform the managers of these agencies about the HEA and the progress made to date.

### 2.3.3 Lower Yuba River Symposium

On July 7, 2009, the Steering Committee attended the Lower Yuba River Symposium, which provided an update on fisheries monitoring activities being conducted by the Lower Yuba River Accord River Management Team (RMT). The Steering Committee had received questionnaires for potential actions on the lower Yuba River, and attendance at this meeting brought about a better understanding of the Lower Yuba River Accord and the monitoring being conducted on the lower Yuba River. It also gave the members of the Steering Committee the opportunity to meet with members of the RMT to discuss potential habitat expansion actions on the lower Yuba River.

### 2.3.4 Combined Meetings with HEA Signatories and Other Stakeholders

The Steering Committee held several meetings with the HEA signatories and other stakeholders to provide them with an update on the status of the HEA process. The following is a summary of these meetings.

- On June 15, 2009, to inform them about the updated Working List of Potential Actions that was being considered for the HEP. The Steering Committee asked the HEA signatories and other stakeholders to provide feedback on the approach for applying the HEA criteria and quantification methods. Comments were received from DFG, USFWS, and American Rivers.

- On August 12, 2009, to review the revised approach for applying the HEA criteria and to present the Ranked Preliminary List of Viable Actions. The Steering Committee asked that the HEA signatories and other stakeholders provide comments on the revised approach for applying the HEA Evaluation Criteria and on the Ranked Preliminary List of Viable Actions.
- On October 15, 2009, to present the List of Viable Actions, the method for determining contribution to the HET, and the actions under consideration for the draft HEP.

### 2.3.5 Communication on Specific Habitat Expansion Actions

The Steering Committee has been communicating through meetings, emails, and informal phone calls with HEA signatories and other stakeholders in targeted watersheds to further develop the habitat expansion actions considered in this draft HEP. The Steering Committee coordinated specifically with the following groups:

- Chico State University (CSU), Chico Research Foundation, and DFG regarding rehabilitation of the Iron Canyon Fish Ladder on Big Chico Creek;
- DFG and the RMT regarding potential habitat expansion actions proposed for the Lower Yuba River;
- Deer Creek Watershed Conservancy regarding supplementing flows, improving fish passage, and rehabilitating floodplain habitat on Deer Creek;
- Mill Creek Management Team (members include Mill Creek Conservancy, DFG, DWR, and Los Molinos Mutual Water Company) regarding the development of dedicated instream flows for Mill Creek; and
- USFWS, Anadromous Fish Restoration Program (AFRP), and DFG regarding construction of a bridge at Paynes Crossing on Antelope Creek.

### 2.3.6 Coordination with Landowners

With the submittal of the draft HEP, the Licensees will continue outreach efforts to other stakeholders. In addition, the Licensees sent a letter and copy of this plan to landowners in the vicinity of recommended actions, informing them of the HEA and the proposed restoration efforts for spring-run Chinook salmon habitat. The letter invites the landowners to comment on the draft HEP and informs them that a public meeting will be held on the actions under consideration in their area. Chapter 10 describes proposed continued outreach efforts in further detail.

Chapter 3
# Application of HEA Criteria

The HEA identifies several criteria for identifying, evaluating, recommending, and approving habitat expansion actions. The Steering Committee developed working definitions for the various HEA criteria (Appendix B) to facilitate utilization of these criteria for selecting actions to be included in the HEP. The Steering Committee prepared a detailed approach for applying the HEA Criteria to potential habitat expansion actions. The following sections describe the approach that was followed to apply the HEA Criteria and develop the various lists of actions (found in Appendix C), culminating in development of the recommended actions in this draft HEP.

## 3.1 HEA Criteria and Criteria Definitions

The HEA identifies several criteria for identifying, evaluating, recommending, and approving habitat expansion actions, including:

- HEA Evaluation Criteria (see Section 4.1.1 of the HEA),
- HEA Selection Criteria (see Section 4.1.2 of the HEA), and
- NMFS Approval Criteria (see Section 4.2.3 of the HEA).

The Steering Committee developed working definitions for the various HEA criteria (Appendix B) to facilitate utilization of these criteria for selecting actions to be included in the HEP. Criteria definitions draw on the concepts captured in the HEA, current scientific literature, recovery plans, and other sources. The Steering Committee requested feedback on the working definitions from NMFS, the HEA signatories, and other stakeholders to further develop these definitions in order to consistently apply the criteria when identifying, evaluating, and recommending habitat expansion actions. Based on comments received, the Steering Committee revised the working definitions and presented them to the HEA signatories and other interested stakeholders at the August 12, 2009 informational meeting.

The *Working Definitions of Evaluation, Selection, and Approval Criteria* are available on the HEA website and are presented in Appendix B. The Evaluation, Selection, and Approval Criteria are explained briefly below.

### 3.1.1 Evaluation Criteria

According to Section 4.1.1 of the HEA, "Evaluation Criteria," the Licensees were to use 17 non-exclusive and non-prioritized Evaluation Criteria to screen potential habitat expansion action(s) and develop a Preliminary List of Viable Actions. The Evaluation Criteria include the following:

(a) favorable feasibility (technically feasible; supported by accepted science; low potential for disease and other risks; proven actions are favored over experimental actions);

(b) adequate scale of expansion of spawning, rearing, and adult holding habitat (one or more larger contiguous gains is favored over numerous smaller gains; increased habitat is favored over enhanced habitat);

(c) favorable sustainability of action;

(d) favorable cost-effectiveness and economic feasibility (including consideration of costs necessary to operate and maintain the expansion);

(e) minimal human intervention needed to achieve access to expanded spawning, rearing and adult holding habitat (volitional access is favored over that which requires a high degree of human intervention);

(f) favorable spatial separation from other populations or runs to maintain genetic diversity by minimizing interbreeding;

(g) favorable spatial separation from other spawning streams to minimize population impacts of a stream-specific adverse event (geographic distribution is favored over centralization);

(h) acceptable length of time to implement (earlier gains are favored over later gains);

(i) favorable local/political support;

(j) consistency with NMFS Viable Salmonid Population guidance, ESA recovery goals and recovery plan (as available), and expected contribution to species recovery (higher consistency and greater contributions are favored);

(k) balance of benefits to spring-run and steelhead (actions that provide a balance of benefits to both spring-run and steelhead are favored over actions that primarily benefit one species; if multiple actions are undertaken, a combination of actions that provides a balance of benefits to both spring-run and steelhead is favored);

(l) consistency with other resource uses such as water supply, public safety, flood control, recreation, and power production;

(m) favorable relative availability of appropriate stocks of spring-run and steelhead for reintroduction;

(n) low expectation for the action to be undertaken by the Licensees or others in the near future;

(o) favorable potential to benefit other anadromous, catadromous and resident fisheries affected by the Feather River Hydroelectric Projects;

(p) low expectation for adverse impact on listed species and destruction or adverse modification of critical habitat under the ESA (actions with low or no impact are favored); and

(q) low potential for an adverse impact on historic or cultural resources.

## 3.1.2 Selection Criteria

According to Section 4.1.2 of the HEA, "Selection Criteria," after developing a Preliminary List of Viable Actions using the Evaluation Criteria set forth in Section 4.1.1 of the HEA, the Licensees will use the four non-prioritized Selection Criteria to select recommended habitat expansion action(s) for implementation. The Selection Criteria include the following:

(a) contribution to achieving the HET;

(b) most cost-effective compared to other potential habitat expansion actions;

(c) feasibility (action[s] can reasonably be accomplished); and

(d) timing (action[s] can be accomplished in a reasonable period of time).

## 3.1.3 Approval Criteria

According to Section 4.2.3 of the HEA, "NMFS Approval Criteria," NMFS will use the Approval Criteria to determine whether to approve the final HEP. NMFS will review information submitted by the Licensees, comments received from other parties to the HEA and other stakeholders, and any other relevant information to consider the extent to which the habitat expansion action(s) recommended in the HEP meet the six NMFS Approval Criteria. The Approval Criteria include the following:

(a) estimated to meet the HET;

(b) assures necessary testing, operation and maintenance;

(c) supports establishing a geographically separate, self-sustaining population of spring-run;

(d) supports segregating spring-run habitat from Central Valley fall-run Chinook salmon;

(e) meets the requirements for eligible habitat expansion action(s) pursuant to Section 3 of this Agreement; and

(f) expected to be implemented within a reasonable period of time.

The habitat expansion action(s) recommended by the Licensees are not required to meet all six Approval Criteria. According to Section 4.2.4 of the HEA, NMFS may approve recommended habitat expansion action(s) that meet at least the following four Approval Criteria: (a), (b), (e), and (f). That is, NMFS can approve actions recommended by the Licensees that do not support establishing a

geographically separate, self-sustaining population of spring-run Chinook salmon and that do not support segregating spring-run Chinook salmon habitat from Central Valley fall-run Chinook salmon.

# 3.2 Applying the HEA Criteria

The Steering Committee prepared a detailed approach for applying the HEA Criteria to potential habitat expansion actions. The Evaluation Criteria were applied to the List of Potential Actions to develop a Ranked Preliminary List of Viable Actions; and the Selection Criteria were then applied to the Ranked Preliminary List of Viable Actions to develop a Ranked List of Viable Actions. Based on how they rated against the overall HEA Criteria, actions were selected from the Ranked List of Viable Actions to become recommended actions.

The following sections describe the approach that was followed to apply the HEA Criteria and develop the various lists of actions, culminating in development of the recommended actions.

## 3.2.1 Developing Habitat Expansion Actions

The first step for developing a list of habitat expansion actions that could potentially be considered for the HEP included developing a comprehensive List of Potential Actions. The Steering Committee created three consecutive lists of actions when developing the List of Potential Actions. These lists include the:

- Draft Working List of Potential Actions,
- Working List of Potential Actions, and
- Short List of Potential Actions.

The process for developing each list is described below.

### 3.2.1.1 Draft Working List of Potential Actions

The Steering Committee initially developed a Draft Working List of Potential Actions to be considered for inclusion in the HEP (Appendix C1). This list was primarily developed from:

- the results of a separate PG&E/CalTrout effort to develop a list of prioritized actions that could contribute to salmon and steelhead recovery,
- recovery actions identified in the NMFS Co-Managers Review Draft Recovery Plan; and

- input received from other parties to the HEA who submitted completed HEA questionnaires and contact information/comment sheets to the Steering Committee.

Other tools used during the development of the Draft Working List of Potential Actions include a geographic information system (GIS) database, which compiled data for various watersheds in the Upper Sacramento River Basin, and a report providing background information on the status of spring-run Chinook salmon and steelhead populations throughout watersheds in the Sacramento River Basin. These tools, which supported the Steering Committee in the identification, evaluation, and selection of potential habitat expansion actions, are described in the following sections.

## Prioritized Actions Contributing to Salmon and Steelhead Recovery

In late 2005, PG&E and CalTrout initiated the Prioritized Actions Contributing to Salmon and Steelhead Recovery Project that involved participation of a broad set of private and public stakeholders, including NMFS, USFWS, DFG, and the Association of California Water Agencies. The purpose of this collaborative effort was to develop a prioritized list of recovery opportunities for Central Valley salmon and steelhead listed under the federal Endangered Species Act (ESA) that is independent of, and complementary to, ongoing recovery efforts undertaken by federal and state agencies. More than 200 potential recovery actions were identified and evaluated as part of this process. In addition, a prioritization tool was developed and applied to many of the actions. The Steering Committee used the list produced by the PG&E/CalTrout project as the starting point for developing the Preliminary List of Potential Actions.

## NMFS Co-Manager Review Draft Recovery Plan

NMFS is developing a recovery plan for listed Central Valley salmon and steelhead. NMFS has stated that implementation of the recovery plan for the Sacramento River winter-run Chinook salmon Evolutionary Significant Unit (ESU), Central Valley spring-run Chinook salmon ESU, and Central Valley steelhead Distinct Population Segment (DPS) is vital to the continued persistence and recovery of these species. Recovery plans are developed to serve as a guideline for achieving recovery goals by describing the steps that must be taken to achieve viable ESUs/DPSs.

NMFS issued the Co-Manager Review Draft Recovery Plan in May 2008. Although the plan was still in development, the Steering Committee obtained permission to use the Co-Manager Review Draft in order to identify additional recovery actions for spring-run Chinook salmon and steelhead. The Steering Committee integrated actions in the Co-Manager Review Draft Recovery Plan into the Draft Working List of Potential Actions.

In October 2009, NMFS issued the *Public Draft Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-Run Chinook Salmon and Central Valley Spring-Run Chinook Salmon and the Distinct Population Segment of Central Valley Steelhead* (Public Draft Recovery Plan). The Public Draft Recovery Plan stipulates that the document should not be cited; however, actions proposed in the draft HEP were referenced against the recommendations in that document.

## Signatory and Stakeholder Input

The Steering Committee prepared a questionnaire to obtain information on potential habitat expansion actions from the signatories to the HEA and other stakeholders. The questionnaire was developed to solicit ideas for actions that could contribute to the expansion of anadromous fish habitat in the Sacramento River basin and be considered for inclusion in the HEP. The type of information requested in the questionnaire assisted the Steering Committee in determining the potential of an action to meet the HEA criteria and includes:

- action contact information,
- description of the action,
- species-limiting factors,
- environmental objectives (i.e., how the action is intended to change the environment in order to achieve the biological objectives),
- biological objectives (i.e., the anticipated biological response from the action),
- cost,
- schedule,
- feasibility,
- support, and
- supporting documents.

Questionnaires and comment forms were posted on the website along with detailed instructions on their completion and submittal. Questionnaires and comment forms completed by the HEA signatories were submitted to the Steering Committee by February 27, 2009. Questionnaires completed by other stakeholders were submitted to the Steering Committee by April 30, 2009. The Steering Committee received 22 completed questionnaires.

## GIS Database for Potential Actions

The Steering Committee requested DWR staff to develop a GIS database compiling appropriate data for various watersheds in the Upper Sacramento River Basin to support the identification and evaluation of potential habitat

expansion actions. The GIS database is focused on the following watersheds: Clear, Cow, Bear, Cottonwood, Beegum, Battle, Antelope, Thomes, Mill, Deer, Butte, Stony, and Big Chico Creeks and the Sacramento, Feather, Yuba, and American Rivers. The database was developed for internal use to assist with selection of potential habitat expansion actions.

The types of data that were incorporated into the GIS database include base information (e.g., roads, towns, cities, public lands, and county boundaries); water features (e.g., rivers, streams lakes, ponds, and reservoirs); watershed boundaries; Digital Elevation Models (DEMs); 1:24K U.S. Geological Survey topographic maps; aerial photographs; satellite imagery; land use data; current and historical distribution of anadromous fish; designated critical habitat for spring-run Chinook salmon and Central Valley steelhead; dams, water diversions, and other potential fish passage barriers; ongoing and completed watershed restoration projects; and available data on salmonid habitat.

## Background Report

The Steering Committee requested DWR to staff prepare a *Background Report on the Status of Spring-Run Chinook Salmon and Central Valley Steelhead in the Sacramento River Basin* (Background Report) (Appendix D). The purpose of this report was to provide background information on the status of spring-run Chinook salmon and Central Valley steelhead populations throughout watersheds in the Sacramento River Basin in order to support the Steering Committee in the identification, evaluation, and selection of potential habitat expansion actions.

The report includes two main sections, addressing: (1) the general life history of spring-run Chinook salmon and steelhead in the Sacramento River Basin; and (2) the status of populations in individual tributaries of the Upper Sacramento River Basin.

The first part of the report covering general life history includes information about:

- basic life history characteristics of the species,
- their historical and current distribution, and
- results of the Population Viability Assessment completed in support of NMFS recovery planning for the species.

The second part of the report addresses the following tributary watersheds: Clear, Cow, Bear, Cottonwood, Beegum, Battle, Antelope, Thomes, Mill, Deer, Butte, Stony, and Big Chico Creeks and the Yuba and American Rivers. Specific topics that are addressed for each tributary watershed include:

- an evaluation of available watershed assessment data, including potential spawning, summer holding, and rearing habitat, as well as known limiting factors for spring-run Chinook salmon and steelhead populations;

- historical and current adult monitoring activities;
- completed, ongoing, and other identified restoration activities;
- limitations for restoration; and
- potential benefits of restoration.

#### 3.2.1.2 Working List of Potential Actions

As a result of the actions and resources described in Section 3.2.1.1 of this plan, completed actions were removed from the Draft Working List of Potential Actions, and new actions were added to the list. Actions that were not viable[1] were removed from the list as well. The Steering Committee then grouped actions within watersheds where applicable.

The result of this approach was a Working List of Potential Actions (Appendix C2).

#### 3.2.1.3 Short List of Potential Actions

The Steering Committee next identified those (single and grouped) actions from the Working List of Potential Actions with a high estimated contribution to the HET. Professional judgment was used to identify actions that would likely add habitat to support at least 500 spring-run Chinook salmon, as well as steelhead.

The result of this approach was a Short List of Potential Actions that included individual and grouped actions (Appendix C3).

### 3.2.2 Applying Evaluation Criteria

Section 4.1.1 of the HEA identifies that "the Licensees shall use the…non-exclusive and non-prioritized Evaluation Criteria to screen potential habitat expansion action(s) and develop a preliminary list of viable actions." Evaluation Criteria scores were applied to the actions in the Short List of Potential Actions to develop a Ranked Preliminary List of Viable Actions (Appendix C4). The scoring rationale is described below.

A scale of 1 to 5 was used to score how each action met each of the 17 HEA Evaluation Criteria. No zero values were used in this scoring process. If an action fully met a criterion, it was given a score of 5. If an action failed to meet a criterion, it was given a score of 1. The intermediate degree to which actions did or did not meet a criterion determined a score of 2, 3, or 4.

[1] Actions that were not viable contained some feature that would prevent the action from being implemented under the terms of the HEA. For example, lack of support by a regulatory agency could prevent the action from receiving permits that may be required before the action could be implemented.

(a) Feasibility – The primary components of this criterion were technical feasibility, support by accepted science, and proven methodology (i.e., not experimental). If an action met the three primary components of criterion (a), it was given a score of 5; if one or two of the components were not met, the action scored a 3; if none of the three components was met, the action scored a 1.

(b) Scale – The primary components of this criterion are the estimated contribution to the HET, representing amount of habitat gain; benefits provided to the three habitat types identified in the goal of the HEA (i.e., spawning, rearing, and adult holding habitat); and the type of habitat expansion (i.e., increase in habitat versus enhancement of existing habitat). Actions resulting in a large gain of potential spawners, an increase in habitat, and benefits to all three habitat types received a score of 5; actions resulting in a moderate gain of potential spawners and addressing at least one habitat type either through increased or enhanced habitat received a score of 3; actions with a low gain of potential spawners and poor habitat quality received a score of 1.

(c) Sustainability – The lifespan and the degree to which an action was self-sustaining (i.e., requiring a minimum amount of maintenance) are the primary components of this criterion. Actions that provided a solution with a long lifespan and minimal maintenance throughout the lifespan of the action received a score of 5; actions that provided limited-term solutions, required annual maintenance, and/or relied on long-term agreements received a score of 3; actions with a short lifespan and requiring a high degree of maintenance received a score of 1.

(d) Cost Effective – The estimated net increase in the population related to the total cost of the action and annual operations and maintenance (O&M) costs are the primary components of this criterion. Actions estimated to have low capital and O&M costs along with a moderate to high contribution to the HET received a score of 5; actions with moderate capital and/or O&M costs and with a low to moderate contribution to the HET received a score of 3; actions with high capital and high O&M costs that outweigh the potential contribution received a score of 1.

(e) Minimal Intervention – Actions were scored based on the level of human intervention required for habitat expansion during the lifespan of the action. Self-sustaining actions that required no maintenance received a score of 5; actions that required minimal to moderate annual O&M and no handling of fish received a score of 3; actions that required intensive handling of fish along with high O&M received a score of 1.

(f) Separation (Genetic) – The actions were scored based on the degree to which they would provide for the spatial segregation of fall-run and spring-run Chinook salmon. Actions that would provide spatial separation between fall-run and spring-run Chinook salmon either by volitional passage into the upper watershed or by a physical barrier received a score of 5; actions that would promote spatial separation by addressing spring-run Chinook salmon life history strategies (e.g., springtime flows) received a score of 3; actions that would not provide or promote spatial separation received a score of 1.

(g) Separation (Catastrophe) – The actions were scored based on the degree to which they would provide for protection against catastrophic events (e.g., volcanic eruption or wildfire) potentially impacting existing independent, self-sustaining spring-run Chinook salmon populations in Mill, Deer, and Butte Creeks. If an action is within a watershed that is outside the predicted range of large-scale catastrophic events (e.g., eruption of Mt. Lassen or Mt. Shasta), it received a score of 5; if an action is within a watershed that is in the range of a smaller-scale catastrophic event (e.g., wildfire) it received a score of 3; if an action is within a watershed supporting an independent, self-sustaining population (i.e., Mill, Deer, or Butte Creek) it received a score of 1.

(h) Time to Implement – If the action could begin implementation (i.e., receive permits and break ground) within approximately 5 years, it received a score of 5; if the action could begin implementation within approximately 5 to 10 years, it received a score of 3; if an action would likely take more than 10 years to begin implementation, it received a score of 1.

(i) Local/Political Support – If support for an action was anticipated from all HEA signatories and local stakeholders, it received a score of 5; if the action had some support, but also some known opposition from either HEA signatories or local stakeholders, it received a score of 3; if an action had substantial opposition and little or no support from HEA signatories or local stakeholders, it received a score of 1.

(j) VSP/ESA Consistency – The actions were scored based on the degree to which they were consistent with the viable salmonid populations (VSP) concept. Because there are four components to the VSP concept (i.e., abundance, productivity, biological diversity, and spatial structure), actions anticipated to contribute to all four components were given a score of 5; contribution to three components was given a score of 4; contribution to two components was given a score of 3; and contribution to one component was given a score of 2. If an action was not anticipated to contribute to any of the VSP components, it was given a score of 1.

(k) Balance of Benefits – If an action was anticipated to result in equal benefits to both spring-run Chinook salmon and steelhead, it received a score of 5; actions with moderately more benefits to spring-run Chinook salmon than steelhead received a score of 3; actions specifically targeting spring-run Chinook salmon and providing no benefit to steelhead received a score of 1.

(l) Resource Consistency –There are five primary components to this criterion: water supply, public safety, flood control, recreation, and power production. Actions that would not negatively affect any of these components received a score of 5. For each component the action could adversely affect, the score was reduced by 1.

(m) Available Stocks – If an action would occur in a watershed with an independent, self-sustaining population, it received a score of 5; actions in watersheds with extant, remnant populations received a score of 4; actions in watersheds where a population could be re-established via straying from a nearby watershed received a score of 3; actions in watersheds where a

population could be re-established via straying from more distant streams, increasing time to realize benefits, received a score of 2; actions in watersheds where the population would need to be re-established by inter-basin transfer of fish received a score of 1.

(n) Action Taken by Others – Actions that were not likely to be taken by others within the foreseeable future (e.g., approximately 5 years) received a score of 5; actions with potential to be taken by others within the foreseeable future received a score of 3; actions likely to be taken by others within the foreseeable future received a score of 1.

(o) Other Feather River Species – Actions that would provide identifiable benefits to the entire community of fishes native to the Feather River received a score of 5; actions that would provide benefits to some of the native fishes received a score of 3; those that would provide benefits to only spring-run Chinook salmon and steelhead received a score of 1.

(p) Adverse Effects (Listed Species) – If an action was not expected to adversely affect listed species or their critical habitat, it received a score of 5. If an action could result in minimal impacts that could be mitigated, it received a score of 3. If an action could cause impacts that could not be mitigated, it received a score of 1.

(q) Adverse Effects (Cultural) – If an action was not expected to adversely affect historic or cultural resources, it received a score of 5. If an action could result in minimal impacts that could be mitigated, it received a score of 3. If an action could cause impacts that could not be mitigated, it received a score of 1.

Scoring the Short List of Potential Actions by the Evaluation Criteria resulted in the Ranked Preliminary List of Viable Actions found in Appendix C4.

## 3.2.3 Applying Selection Criteria

Section 4.1.2 of the HEA explains that "[a]fter developing a preliminary list of viable habitat expansion action(s) using the Evaluation Criteria set forth in Section 4.1.1…, the Licensees shall use the…non-prioritized Selection Criteria to select recommended habitat expansion action(s) for implementation." After the Evaluation Criteria were applied, the Ranked Preliminary List of Viable Actions was reevaluated and shortened based on new information. Selection Criteria scores were applied to the remaining actions, resulting in the Ranked List of Viable Actions (Appendix C5). The scoring rationale is described below.

Consistent with the methodology used for the Evaluation Criteria, a scale of 1 to 5 was used to score how well each action met each of the Selection Criteria. No zero values were used in this scoring process.

(a) Contribution to the HET – The procedure described in Chapter 4 was used to estimate how many additional fish the area of the watershed might support for each action or group of actions. Because a number of assumptions were made to arrive at the estimates, the contribution to the HET for a particular

action or group of actions was assigned a score of 1, 3, or 5 based on the estimate. A score of 1 was used for those actions that would not meet the HET, a score of 3 was used for those actions that would meet the HET, and a score of 5 was used for those actions that would exceed the HET. Scores were assigned to all of the actions or groups of actions on the Ranked Preliminary List of Viable Actions.

(b) Cost effectiveness compared to other actions on the Ranked Preliminary List of Viable Actions – The actions were assessed based on a relationship between cost and contribution to the HET, consistent with the working definitions of the HEA criteria (Appendix B). Cost effectiveness was assigned a score of 1, 3, or 5 based on how cost effective the action or group of actions was compared to the others on the Ranked Preliminary List of Viable Actions. The total estimated cost of each action or group of actions was divided by the estimated contribution to the HET in order to calculate an estimated cost-per-fish. The estimated cost-per-fish for each action or group of actions was then divided by the highest cost-per-fish action. This approach enabled a comparison of the cost effectiveness of the actions on the Ranked Preliminary List of Viable Actions. Scores were assigned to the actions based on resulting values. A score of 1 was assigned to the actions that fell in the highest 10% (most expensive per fish) of all the actions, a score of 3 was assigned to the actions that fell in the middle of the range, and a score of 5 was assigned to the action that fell in the lowest 10% (least expensive per fish).

(c) Feasibility – Feasibility was based on four of the Evaluation Criteria: (a) feasibility; (d) cost-effectiveness; (i) local/political support; and (l) resource consistency. The scores of these four Evaluation Criteria were combined to develop a single feasibility score for each action or group of actions. Specifically, an average of the four Evaluation Criteria scores was used to determine the feasibility score for the actions.

(d) Timing – The Evaluation Criterion (h) time to implement, score was used to score the timing for the Selection Criteria as well.

The scores resulting from application of the four Selection Criteria were added to yield a total score. The next step was to combine the scores from the Selection Criteria with the scores from the Evaluation Criteria in order to identify which actions best met these two elements of the HEA. This was achieved by weighting the Evaluation Criteria. The Evaluation Criteria weighting was determined by dividing the “Total Score” for each action or group of actions from the Ranked Preliminary List of Viable Actions by the highest total score. Scores from the Selection Criteria were then multiplied by these weights, thereby utilizing the Evaluation Criteria scores while not diminishing the importance of the Selection Criteria. The resultant scores were normalized.

The results of scoring the Ranked List of Viable Actions by the Selection Criteria are found in Appendix C5.

action or group of actions was assigned a score of 1, 3, or 5 based on the estimate. A score of 1 was used for those actions that would not meet the HET, a score of 3 was used for those actions that would meet the HET, and a score of 5 was used for those actions that would exceed the HET. Scores were assigned to all of the actions or groups of actions on the Ranked Preliminary List of Viable Actions.

(b) Cost effectiveness compared to other actions on the Ranked Preliminary List of Viable Actions – The actions were assessed based on a relationship between cost and contribution to the HET, consistent with the working definitions of the HEA criteria (Appendix B). Cost effectiveness was assigned a score of 1, 3, or 5 based on how cost effective the action or group of actions was compared to the others on the Ranked Preliminary List of Viable Actions. The total estimated cost of each action or group of actions was divided by the estimated contribution to the HET in order to calculate an estimated cost-per-fish. The estimated cost-per-fish for each action or group of actions was then divided by the highest cost-per-fish action. This approach enabled a comparison of the cost effectiveness of the actions on the Ranked Preliminary List of Viable Actions. Scores were assigned to the actions based on resulting values. A score of 1 was assigned to the actions that fell in the highest 10% (most expensive per fish) of all the actions, a score of 3 was assigned to the actions that fell in the middle of the range, and a score of 5 was assigned to the action that fell in the lowest 10% (least expensive per fish).

(c) Feasibility – Feasibility was based on four of the Evaluation Criteria: (a) feasibility; (d) cost-effectiveness; (i) local/political support; and (l) resource consistency. The scores of these four Evaluation Criteria were combined to develop a single feasibility score for each action or group of actions. Specifically, an average of the four Evaluation Criteria scores was used to determine the feasibility score for the actions.

(d) Timing – The Evaluation Criterion (h) time to implement, score was used to score the timing for the Selection Criteria as well.

The scores resulting from application of the four Selection Criteria were added to yield a total score. The next step was to combine the scores from the Selection Criteria with the scores from the Evaluation Criteria in order to identify which actions best met these two elements of the HEA. This was achieved by weighting the Evaluation Criteria. The Evaluation Criteria weighting was determined by dividing the “Total Score” for each action or group of actions from the Ranked Preliminary List of Viable Actions by the highest total score. Scores from the Selection Criteria were then multiplied by these weights, thereby utilizing the Evaluation Criteria scores while not diminishing the importance of the Selection Criteria. The resultant scores were normalized.

The results of scoring the Ranked List of Viable Actions by the Selection Criteria are found in Appendix C5.

Chapter 4
# Contribution to the HET

This chapter presents the conceptual framework and procedure used to estimate the contribution to the HET for the recommended actions, herein referred to as the *HET contribution procedure*. The following sections describe the scientific rationale underlying the Licensees' approach to determining the contribution of a recommended action to the HET. A summary of applying this procedure to the individual actions is provided in Appendix E. As stated in Section 6.1 of the HEA, the Licensees are not obligated to guarantee or verify fish production or utilization. The estimated contribution of an action to the HET represents an index of the increase in quality and quantity of habitat for spring-run Chinook salmon. Actual results of the actions could differ due to a variety of factors.

## 4.1 HEA Conceptual Framework

A conceptual framework describes how information is interpreted, how problems are identified, and a range of appropriate solutions (Williams 2006). The HEA conceptual framework describes the scientific vantage point used by the Licensees to address the HEA and is the basis for the approach taken to evaluate proposed actions and their potential contribution to the HET.

The starting point for the conceptual framework is the HEA itself. The goal of the HEA is to "expand spawning, rearing and adult holding habitat sufficient to accommodate an estimated net increase in of 2,000 to 3,000 Spring-Run Chinook for spawning ("Habitat Expansion Threshold"), in the Sacramento River Basin as compared to the habitat available under any relevant Existing Requirements or Commitments" (Section 2.2 of the HEA) The interpretation of this goal in the HEA conceptual framework is that habitat expansion is synonymous with an increase in the potential of habitat in the Sacramento River system to support spring-run Chinook salmon relative to the current potential of the habitat. Increasing habitat potential requires increasing areas in the Sacramento River system with characteristics consistent with the biological requirements of spring-run Chinook salmon.

The following sections define habitat potential and compare the relationship of the HEA to the VSP concept.

### 4.1.1 Habitat Potential

*Habitat* refers to features of the environment required by the species to complete its life history (Hall et al. 1997). For the HEA, habitat is an interpretation of the environment "through the eyes of salmon" (Mobrand et al. 1997). Habitat conditions ultimately set the limits of biological performance of individual species (Southwood 1977). In the case of anadromous salmonids, habitat reflects their migratory life history and describes conditions across a pathway of freshwater, estuarine, and marine environments.

*Habitat potential* is the capability of an environmental condition to support a species, in this case spring-run Chinook salmon. Habitat potential is based on the genetically determined tolerances of the species and the quantity and quality of habitat available to the species in a particular environment over the course of its life history. The expected abundance of fish that can be supported by a given environmental condition is a useful measure of habitat potential. Actual abundance of spring–run Chinook observed in any year reflects natural environmental variation and the effect of non-habitat factors (e.g., harvest).

*Quantity of habitat* relates to the amount of suitable habitat available at the correct time and place to allow the species to complete its life history. The amount of suitable habitat relates to the biological capacity of the system for the species. It is intuitive that the amount of habitat available in an environment is capable of supporting only a limited number of individuals. Thus, quantity of habitat sets the "size" of the environment and the biological capacity of the system.

*Quality of habitat* refers to the characteristics of the environment that determine survival (often referred to as *productivity*) of the species (e.g., temperature, water quality, and structure). These quality attributes are limited in any environment and constrain the overall carrying capacity. Fish move between life stages across time and space experiencing habitat of varying quantity and quality. The quantity and quality of habitat available over the course of the species' life history determines the potential performance of the species in the environment.

Applied to the HEA, quantity and quality of habitat in the Sacramento River system set the biological capacity and productivity of the environment and determine the potential of the Sacramento River system to support spring-run Chinook salmon. Habitat expansion actions can increase habitat potential by adding to the quantity of habitat (e.g., by removing a passage barrier) or by enhancing the quality of currently accessible habitat (e.g., by decreasing water temperature).

Habitat potential varies widely across time and space due to intrinsic features of the environment, variation in conditions (e.g., interannual river flow differences), and human impacts on the environment. Each stream in the Sacramento River system has intrinsic habitat limitations: watersheds are only of a certain size; flow patterns reflect climate and precipitation; and water temperature is constrained by air temperature, flow, and riparian vegetation. Hence, watersheds

in the Sacramento River system have a certain inherent potential to support spring-run Chinook salmon based on these intrinsic environmental characteristics.

These concepts of habitat potential provide a framework for evaluating actions under the HEA (Figure 4-1). Actions are evaluated within a range of environmental conditions bounded by the current and intrinsic environmental conditions[1] (Lichatowich et al. 1995). The intrinsic condition forms a *reference condition* that is compared to the *current condition* to provide a basis for defining factors currently limiting the potential of the current condition and to identify how proposed actions address these limitations. The difference between fish performance under the reference condition and that under the current condition define the *recovery potential* that can be addressed by actions proposed under the HEA (Figure 4-1).

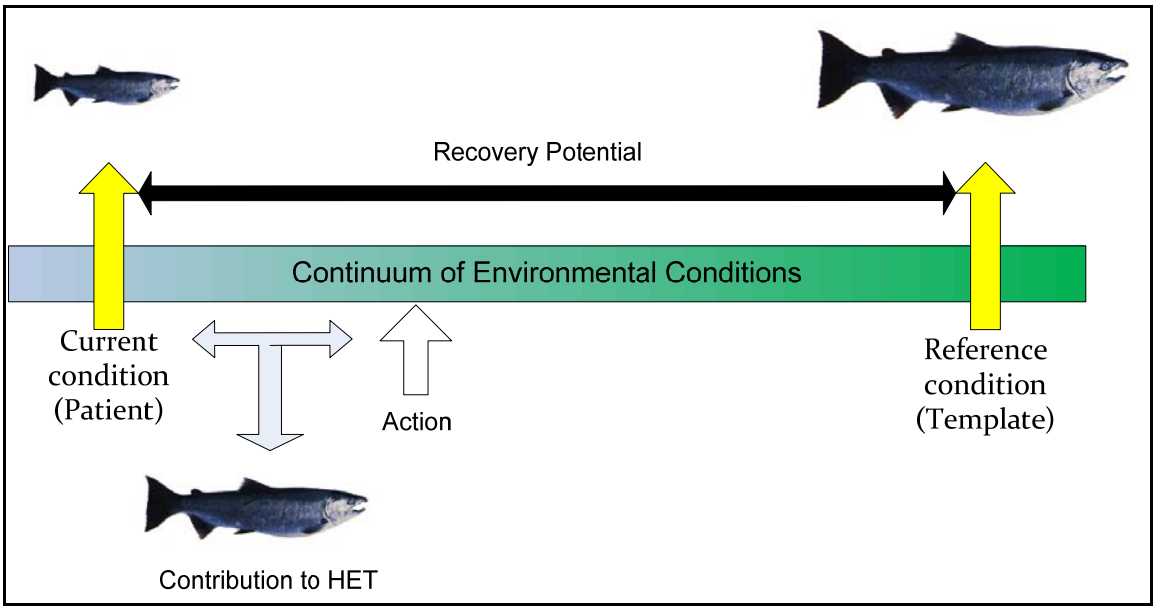


**Figure 4-1.** HEA Conceptual Framework for Evaluating the Contribution of Actions to the Habitat Expansion Threshold

The HEA framework is an application of *Patient-Template Analysis* developed by Lichatowich et al. (1995). In Patient-Template Analysis, the current condition of the watershed (the Patient) is evaluated against a reference condition (the Template) to create a diagnosis of the system. The shortcomings of the stream are then addressed by treatments in the form of habitat restoration and expansion actions. The Template or reference condition creates a "guiding image" for restoration (Palmer et al. 2005). The value of evaluating streams against a reference condition is discussed with regard to the recovery of Central Valley Chinook salmon in Schick and Lindley (2007).

[1] Human actions in a watershed could result in further degradation of the stream and appear to the left of the current condition in Figure 4-1.

The difference between species habitat potential under the current and reference conditions is referred to as the *recovery potential* for spring-run Chinook salmon within a *restoration area*. A restoration area is a watershed or portion of a watershed that is the focus of a proposed habitat expansion action. Habitat potential is measured in terms of the abundance of adult spring-run Chinook salmon expected from a given environmental condition (current, reference, or proposed restoration actions). Contributions to the HET from different recommended actions were compared in terms of the increase in abundance of spring-run Chinook salmon expected from the actions.

In all Sacramento River watersheds, human actions have decreased habitat potential relative to the reference condition. In most of these watersheds, habitat change and other human actions have reduced performance of spring-run Chinook salmon to the point of extirpation and listing under the ESA. Restoration actions proposed under the HEA are intended to increase habitat potential up to the intrinsic limits of the system defined by the reference condition. Actions considered under the HEA can expand the amount of available habitat (e.g., by removing a dam or other blockage to anadromous passage) or enhance the available habitat (e.g., by improving temperature or structure).

This framework provides a standard against which to define “good” and “bad” conditions that recognizes the inherent strengths and limitations of the stream. Future conditions (e.g., restoration actions) can be evaluated within realistic bounds relative to their impact on specific factors limiting performance of the species.

### 4.1.1 Relationship of HEA Actions to the Viable Salmonid Population Concept

NMFS has advanced the concept of VSP as a conceptual framework for consideration of efforts to restore salmonid populations listed under the federal ESA (McElhany et al. 2000). Features of the VSP are woven throughout the HEA. The concept has been expanded and adapted for application to recovery of Central Valley Chinook salmon and steelhead (Lindley et al. 2007). VSP describes the status or “health” of salmonid populations in terms of four criteria: abundance, productivity, biological diversity, and spatial structure.

Abundance and productivity of salmon populations relate to the quality and quantity of habitat (discussed above). *Abundance* is a function of biological capacity and productivity, which are constrained by the quantity and quality of habitat. The framework for consideration of HEA actions uses the abundance of spring-run Chinook salmon as a measure of biological performance, reflecting the quantity and quality of habitat. Small streams or areas with limited capacity need high-quality habitat (high productivity) to be viable and capable of supporting independent populations. Larger streams or areas with greater

capacity can be viable and support independent populations with lower quality habitat (lower productivity) (McElhany et al. 2000).

The VSP criterion of *biological diversity* describes the underlying genetic diversity of salmon. Genetic diversity creates variation in morphology (e.g., size, shape, or color) or behavior (e.g., spawning timing and age at maturation) both within and between salmon populations. Within a species (e.g., Chinook salmon), biological diversity results from adaptation to the variation and diversity in habitat conditions within the physiological tolerances of the species. In terms of habitat, this means that conditions that allow a greater expression of biological diversity should be favored over conditions that narrowly restrict biological diversity. Greater variation in suitable habitat both spatially (e.g., longitudinally along a stream or between streams) and temporally (e.g., days within a year) should support greater biological diversity due to local adaptation. To address this criterion, the actions recommended under the HEA need to enhance the spatial and temporal diversity of conditions suitable for Central Valley spring-run Chinook salmon and steelhead.

*Spatial structure* in VSP refers to the diversity of populations across the landscape. It reflects the pattern of suitable habitat across the Central Valley to support multiple independent populations within and between watersheds. For ESA purposes, NMFS has broadly described spatial structure within a species using the concept of ESU for Pacific salmon (Waples 1995). DPS is a closely related concept that has been applied to steelhead. An ESU/DPS is a group of salmonid populations with sufficient geographic isolation to allow local adaptation and with a shared genetic relationship to the extent that the group collectively has a distinct evolutionary legacy (Waples 1995). NMFS has defined all spring-run Chinook salmon within the Central Valley (all of which are currently in the Sacramento River basin) to constitute an ESU distinct from, for example, Central Valley winter-run Chinook salmon.

Lindley et al (2007) further described the spatial structure of Central Valley spring-run Chinook salmon by creating diversity groups (Table 4-1). Populations within a diversity group reside in streams with similar climatological, hydrological, and geological characteristics. Populations within a diversity group are expected to have some genetic affinity and be exposed to similar types of risks that could lead to extirpation. For this reason, NMFS stresses the need for diversity between diversity groups as well as within diversity groups. Across the Sacramento River basin, the spatial diversity criterion favors creation of suitable conditions to support independent spring-run Chinook salmon populations within multiple diversity groups and watersheds.

**Table 4-1.** Spatial Structure of the Central Valley Spring-Run Chinook Salmon Evolutionary Significant Unit

| Diversity Group | Watershed |
|---|---|
| Basalt and Porous Lava | Battle Creek |
| | Upper Sacramento tributaries (above Shasta Dam) |
| Northern Sierra Nevada | Antelope Creek |
| | Deer Creek |
| | Mill Creek |
| | Butte Creek |
| | Yuba River |
| | Feather River |
| | American River |
| | Mokelumne River |
| Northwestern California | Clear Creek |
| | Cottonwood/Beegum Creek |
| | Thomes Creek |
| | Stony Creek |
| Southern Sierra Nevada (San Joaquin River system) | Stanislaus River |
| | Tuolumne River |
| | Merced River |
| | San Joaquin River |
| | Kings River |

Source: Lindley et al. 2007.

Currently, viable spring-run Chinook salmon populations in the Sacramento River system occur only in Deer, Mill, and Butte Creeks. These populations are small and vulnerable to extirpation. For this reason, NMFS has placed a high priority on establishing new independent populations of spring-run Chinook salmon. The HEA can contribute to that goal by favoring actions that lead to the establishment of a new independent population of spring-run Chinook salmon.

The HEA can also enhance spatial and biological diversity by developing favorable habitat conditions for dependent populations that occur in smaller streams that, by themselves, are not large enough to support an independent fish population. Lindley et al. (2007) concluded that fish in any watershed less than 500 square kilometers form a dependent population that must be supported by stronger independent populations in nearby watersheds. Dependent populations interact with each other and with independent populations to create a metapopulation. Within a metapopulation, fish move between population centers (e.g., streams) and collectively form a genetically identifiable unit that adds to the overall genetic structure of the Central Valley spring-run Chinook salmon ESU.

# 4.2 Procedure for Determining Contribution to the HET

The Licensees developed an approach to evaluate the contribution of each action to the HET that reflected: (1) the limited timeframe allowed under the HEA; and (2) the recognition that data related to habitat characteristics in the Sacramento River system are generally lacking and vary greatly in detail between watersheds. A qualitative approach was devised that used empirical data, as well as the professional judgment of the Steering Committee Technical Team and other experts. The HET contribution procedure utilizes a series of logical steps and a set of assumptions that support conclusions regarding the potential of recommended actions to provide habitat in order to achieve the HET. The procedure offers a consistent and relative approach to comparing the potential contribution of actions to the HET. As stated in Section 6.1 of the HEA, the Licensees are not obligated to guarantee or verify fish production or habitat utilization. The estimated contribution of an action to the HET represents an index of the increase in quality and quantity of habitat for spring-run Chinook salmon. Actual results of the actions could differ due to a variety of factors.

The HET contribution procedure was applied to habitat in a defined portion of a watershed term the *restoration area*. The restoration area may represent all or most of a watershed (e.g., Antelope Creek) or a significant defined portion of a watershed (e.g., the lower Yuba River between Englebright Dam and Daguerre Point Dam). Actions were evaluated in regard to their potential to change habitat conditions in a restoration area that were identified as significant factors limiting spring-run Chinook salmon within the restoration area.

## 4.2.1 General Concept of the HET Contribution Procedure

The HET contribution procedure defines the potential for habitat change as lying between the current and reference conditions (Figure 4-2). The *current condition* captures the environmental conditions and population abundance in the restoration area during recent times. This is compared against conditions and fish abundance under a *reference condition* that is the “guiding image” for the watershed. The reference condition could describe the stream in the absence of significant human-imposed limitations. However, other reference conditions are possible that could account for permanent changes in the watershed imposed by human actions. For example, spring-run Chinook salmon were not abundant in the lower Yuba River historically but instead migrated to holding and spawning habitat in upper parts of the watershed that are now blocked by Englebright Dam. The cool water released from New Bullards Bar Dam provides conditions below Englebright Dam that allow spring-run Chinook salmon to persist. Assuming that the dams are permanent features of the landscape, the historical reference condition is not appropriate, and a new reference condition must be developed that accounts for these permanent features.

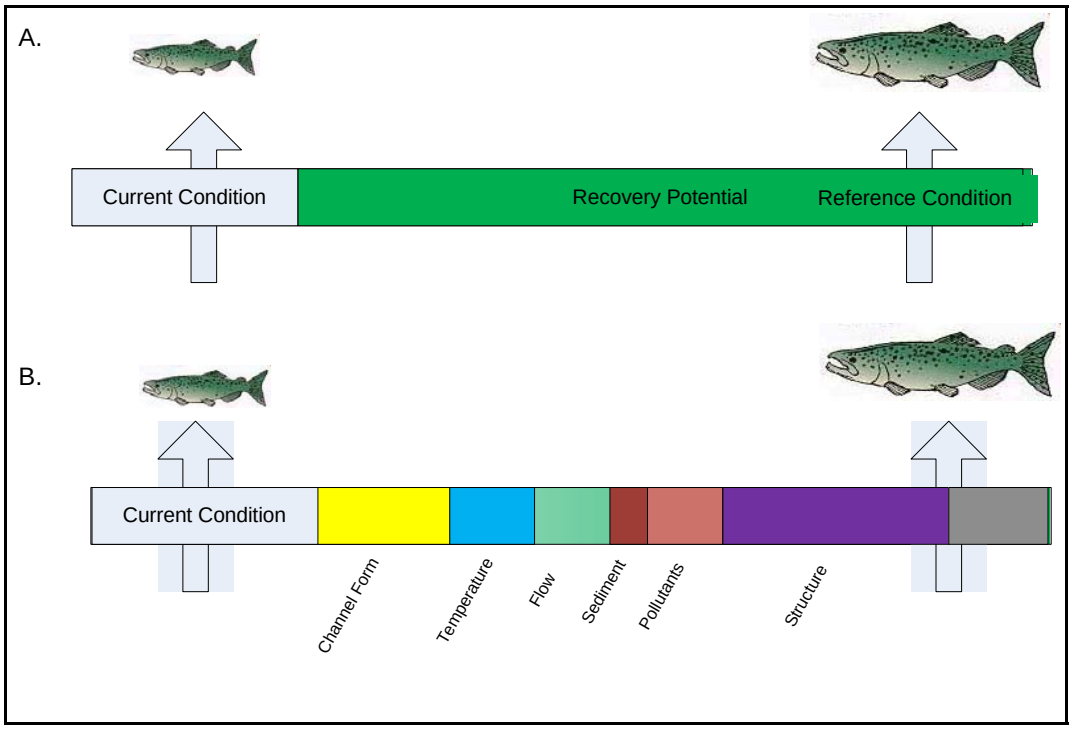


**Figure 4-2.** Adaptation of HEA Conceptual Framework to Determining the Contribution to the Habitat Expansion Threshold

Note: Recovery potential is estimated by comparing abundance under the current condition to abundance under a reference condition (A). Recovery potential is allocated among habitat-limiting factors that are then acted upon by actions recommended under the HEA (B).

The reference condition was compared to the current condition to define the recovery potential of spring-run Chinook salmon in the restoration area (Figure 4-2). The recovery potential was then allocated among a set of environmental attributes. Recovery potential (number of spring-run Chinook salmon) was allocated among the environmental attributes by the amount of habitat change estimated to have occurred in each attribute weighted by a set of biological assumptions (or rules) that provide the species interpretation of environmental change. Proposed actions change the condition of one or more of the environmental attributes, producing a proportional change in the recovery potential allocated to the attributes and a contribution to the HET.

The HET contribution procedure involved three distinct steps:

1. Defining the biological assumptions used to interpret change in environmental conditions from the perspective of spring-run Chinook salmon,
2. Diagnosing conditions within the restoration area, and
3. Applying watershed treatments to address habitat limitations identified in the diagnosis.

These steps are discussed in the following sections using an example evaluation of a set of proposed actions for a hypothetical watershed. The example includes three hypothetical actions that would be applied in a restoration area.

The HET contribution procedure was incorporated into Excel spreadsheets that documented the specific assumptions applied to the evaluation of each proposed action. These spreadsheets can be viewed on the HEA website.

## 4.2.2 Biological Assumptions

The HET contribution procedure involves interpreting change in environmental conditions within the restoration area based on a scientific understanding of the biological and ecological requirements of spring-run Chinook salmon. The biological assumptions (or rules) were used to interpret habitat change from the perspective of spring-run Chinook salmon (Mobrand et al. 1997). The process of defining biological rules can be complex if the effects of many attributes on multiple life stages are considered. For the HET contribution procedure, a simplified approach was used in which a small set of broad environmental attributes was rated for importance to spring-run Chinook salmon. The biological rules are scientific hypotheses that are independent of a particular watershed or set of actions and reflect professional judgments based on the body of scientific knowledge.

The initial task in defining the biological assumptions involved describing the environmental attributes that are potentially limiting factors for spring-run Chinook salmon. Eight physical environmental attributes were defined (Table 4-2). These attributes also were included in the HEA questionnaire, and applicants were asked to characterize proposed actions in terms of their expectation to change one or more environmental attribute.

The environmental attributes were then ranked, using a score of 0 (no importance) to 4 (high importance), in terms of their role in determining biological capacity and productivity for adult spring-run Chinook salmon (Table 4-3). The ranking was based on synthesis of available scientific information and professional judgment. Attributes were ranked separately for small (e.g., Antelope Creek) and large (e.g., the lower Yuba River) streams. For example, large wood structure is likely very important in creating Chinook salmon habitats in small streams but is of lesser importance in large rivers; conversely, the presence of floodplain habitat is more important in larger rivers than in smaller streams, which tend to be confined within steep banks.

**Table 4-2.** Definitions of Environmental Attributes That Are Potentially Limiting Factors for Spring-Run Chinook Salmon

| Environmental Attribute | Definition |
|---|---|
| Channel form | The condition of the channel relative to its normative geomorphic form. Deviation from normative can include channelization, excessive sediment, or bank armoring. |
| Channel unit types | Geomorphic units that form key macrohabitat features for salmonids. Examples are pools, riffles, and glides. Deviation from normative can occur due to loss of structure, channel modification, or flow modification. |
| Substrate | The condition of substrate in the stream, particularly in relation to the quality of spawning habitat. Deviation from normative can include the addition of fine sediment in riffles, scouring of gravel, or excessive deposition of gravel or other material. |
| Structure | The amount of structural elements resulting in habitats and refugia for fish created by large wood, boulders, channel form, or other objects causing local hydrologic disruption. Deviation from normative would primarily be related to the removal of such elements. |
| Flow | The magnitude and pattern of streamflow on a seasonal basis and its effect on depth, velocity, and other important stream characteristics. Deviation from normative can include changes in flow peaks, low flows, flashiness, or temporal shifts in flow patterns. |
| Temperature | The magnitude and pattern of water temperatures on a seasonal basis. Deviation from normative can include high summer water temperatures. |
| Water quality | The quality of water in the stream based on a variety of key water quality parameters. Deviation from normative can include the presence of pollutants or other potentially toxic substances. |
| Riparian/floodplain | The connection of the stream and its floodplain. Deviation from normative can be caused by diking, flow regulation, or channelization. |

**Table 4-3.** Adopted Ranking of Importance of Environmental Attributes in Determining Productivity and Capacity of Spring-Run Chinook Salmon in Two Stream Size Categories.

| | Environmental Attributes | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Stream Size Category** | **Channel Form** | **Channel Unit Types** | **Substrate** | **Structure** | **Flow** | **Temperature** | **Water Quality** | **Riparian/ Floodplain** |
| Large | 3.0 | 3.0 | 3.0 | 1.0 | 2.0 | 4.0 | 1.0 | 2.0 |
| Small | 2.0 | 2.0 | 3.0 | 3.0 | 3.0 | 4.0 | 1.0 | 1.0 |

Note: A score of 0 (no importance) to 4 (high importance) was assigned to environmental attributes to reflect their roles in determining biological capacity and productivity for adult spring-run Chinook salmon.

### 4.2.3 Watershed Diagnosis

Diagnosis of conditions in the restoration area involved estimating change in the condition of the environmental attributes between the current and reference conditions and then interpreting that change through the biological assumptions. The diagnosis included defining the recovery potential within the restoration area. The recovery potential was then allocated among the environmental attributes as shown in Figure 4-2(B) based on the amount of change that has occurred in each attribute between current and reference conditions. Fish abundance was used as a surrogate for a habitat-based calculation of biological capacity. A large stream (e.g., the Yuba River) with larger numbers of spring-run Chinook salmon observed presently or in the past was assumed to have a higher habitat potential for spring-run Chinook salmon than a smaller stream (e.g., Antelope Creek) where lower numbers of Chinook spring-run salmon have been observed.

*Current abundance* was assumed to reflect the existing habitat potential given current habitat constraints. An estimate of current habitat potential (i.e., the current abundance of adult spring-run Chinook salmon) was derived from recent observations of abundance; the average escapement from 1999 to 2008 was calculated using data from the DFG GrandTab database.

*Reference abundance* was used to estimate the habitat potential without the current habitat constraints. For some streams, the reference abundance of adult spring-run Chinook salmon was provided by DFG or other agencies. For other streams, reference abundance was determined based on available historical information.

The difference between the current abundance and the reference abundance defined the recovery potential, as shown in Figure 4-2. For example, if the current abundance of spring-run Chinook salmon in a restoration area is 250 adult spring-run Chinook salmon and the estimate of reference abundance in the area is 1,500 adult spring-run Chinook salmon, the recovery potential of the area would be 1,250 adult spring-run Chinook salmon. The HET contribution procedure assumes that the current low abundance is due to human-caused habitat constraints within the restoration area that could be remedied by potential HEA actions[2].

Physical conditions for the environmental attributes were then compared between the current and reference conditions to evaluate how human actions have changed the environment within the restoration area. The eight environmental habitat attributes in Table 4-2 were ranked from 0 (optimum geomorphic condition) to 4 (highly altered geomorphic condition) for the current and

[2] Abundance of salmon is a function of many factors outside the restoration area, including conditions in the Sacramento River, Bay/Delta, and ocean. Natural variation and human-caused change in conditions in these areas result in significant variation in salmon abundance over the short and long term. For purposes of the HEA, it was assumed that these changes were reflected in both the current and reference conditions; therefore, they were not considered in determining contribution to the HET.

reference conditions. This step involved application of geomorphic science and specific knowledge of the target watershed. Attributes for the reference condition were ranked to recognize intrinsic limitations on the stream imposed by climate, hydrology, or geology. For example, the stream may always have been warm in summer due to a combination of natural low flow and high air temperature. Physical environmental attributes for both the current and reference conditions were scored relative to the optimum geomorphic condition for similar salmon-bearing streams.

Table 4-4 provides an example of environmental rating scores for a restoration area. In this example, relative to the optimum geomorphic condition, flow is the most highly altered attribute in the current condition, although all attributes are currently limited to some degree. The example stream has some intrinsic limitations in several attributes captured in the reference condition—for example, temperature conditions in the stream have always been less than optimum. The rating scores for the two conditions were subtracted to characterize the environmental change (i.e., environmental change score = reference rating score – current rating score). This procedure moderates the characterization of the current condition by the intrinsic condition of the stream.

**Table 4-4.** Example of Environmental Rating Scores for a Sample Stream

| | Environmental Attributes | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Restoration Area** | **Channel Form** | **Channel Unit Types** | **Substrate** | **Structure** | **Flow** | **Temperature** | **Water Quality** | **Riparian/ Floodplain** |
| Current condition | 2 | 2 | 2 | 2 | 3 | 2 | 1 | 2 |
| Reference condition | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 |
| Environmental change | -1 | -1 | -1 | -2 | -3 | -1 | -1 | -2 |

Note: The eight environmental habitat attributes in Table 4-2 were ranked from 0 (optimum geomorphic condition) to 4 (highly altered geomorphic condition) for both the current condition and the reference condition. The rating scores for the two conditions are subtracted to characterize the habitat change (i.e., environmental change score = reference rating score – current rating score).

The raw environmental rating scores in Table 4-4 were then interpreted with regard to habitat for adult spring-run Chinook salmon using the biological assumptions for a small stream in Table 4-3. This was done by multiplying the environmental change score in Table 4-4 by the biological ranking for the attributes in Table 4-3. The weighted habitat change scores were then normalized to 100% (Table 4-5).

The result of this process is a biologically interpreted score (Figure 4-3) for habitat change that takes into account the intrinsic constraints of the watershed. Figure 4-3 shows the effect of the species interpretation of the habitat rating scores on the raw scores for the example stream in Table 4-4. The biological ratings brought several attributes into higher relief, such as flow and structure,

and decreased the importance of others, such as water quality and floodplain condition.

**Table 4-5.** Weighted and Normalized Habitat Change Scores for Chinook Spring-Run Salmon

| | Environmental Attributes | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Habitat Change Score** | **Channel Form** | **Channel Unit Types** | **Substrate** | **Structure** | **Flow** | **Temperature** | **Water Quality** | **Riparian/ Floodplain** |
| Biologically weighted score | -2 | -2 | -3 | -6 | -9 | -4 | -1 | -2 |
| Normalized score | 6.9% | 6.9% | 10.3% | 20.7% | 31.0% | 13.8% | 3.4% | 6.9% |

Note: The environmental change score in Table 4-4 was multiplied times the biological ranking for the environmental attributes in Table 4-3 to arrive at a biologically weighted habitat change score. The weighted habitat change scores were then normalized to 100%.

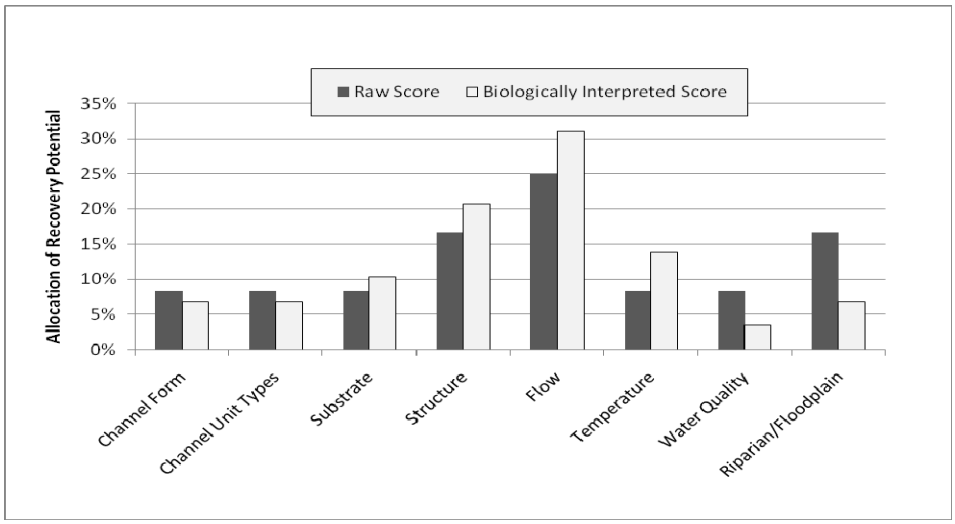


**Figure 4-3.** Comparison of Raw and Biologically Interpreted Habitat Rating Scores for an Example Stream

The final step in the watershed diagnosis is to allocate the recovery potential among the eight habitat attributes. This is done by applying the normalized percentile ratings in Table 4-5 to the estimated recovery potential (1,250 adult spring-run Chinook salmon in the example). The results of this step for the example stream are shown in Table 4-6. This provides an estimate of the number of fish that could be added to the current abundance if each habitat attribute were restored to the reference condition.

**Table 4-6.** Allocation of Recovery Potential Based on the Species-Interpreted Habitat Change Scores (Numbers of Adult Chinook Spring-Run Salmon)

| Environmental and Non-Environmental Attributes | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Passage** | **Channel Form** | **Channel Unit Types** | **Substrate** | **Structure** | **Flow** | **Temperature** | **Water Quality** | **Riparian/ Floodplain** |
| 313 | 65 | 65 | 97 | 194 | 291 | 129 | 32 | 65 |

Note: The normalized percentile ratings in Table 4-5 were applied to the estimated recovery potential (1,250 adult spring-run Chinook salmon in the example stream). This provides an estimate of the number of fish that could be added to the current abundance if each habitat attribute were restored to the reference condition.

The watershed diagnosis includes two non-environmental habitat attributes: passage of adult and juvenile fish, and the proportion of the current abundance comprised of spring-run Chinook salmon. Passage of fish may be impeded by dams or culverts causing a certain level of mortality. For those streams with an identified passage issue, the level of current mortality (expressed as a percentage) was estimated based on available information and was used to modify the recovery potential. The example assumed a passage problem that reduced habitat potential in the restoration area by 25%. This resulted in an allocation of recovery potential to passage of 313 fish (Table 4-6). Table 4-6 shows that 313 spring-run Chinook salmon were allocated to the recovery potential associated with passage, reflecting an assumption that passage of adult (or juvenile) spring-run Chinook salmon was impeded by 25%.

In streams with populations of both spring-run and fall-run Chinook salmon, some level of spawning overlap may need to be considered. Although spawning overlap is believed to occur in certain streams, little data are available to indicate the amount of overlap or the potential harm to the spring-run population. For those streams with evidence of spawning overlap, the proportion of the total Chinook salmon run considered to be spring-run was estimated based on professional judgment and best available information, and the estimate was used to modify the recovery potential. If only 65% of the fish observed in the example restoration area are spring-run Chinook salmon and the remaining fish are fall-run Chinook salmon, the recovery potential associated with each attribute in Table 4-6 would be reduced by 35%.

## 4.2.4 Watershed Treatment

*Treatments* consist of one or more actions that are applied to the current condition to increase the quantity or quality of the habitat, thus increasing current abundance and contributing to the HET. The challenge was to convert descriptions of potential actions into expected change in the condition of one or more of the attributes in Table 4-2. This was accomplished by creating an action hypothesis for each recommended action. The concept of action hypotheses is discussed more fully in ICFI (2009). Action hypotheses were created in two

steps: first, the *potential* of different types of actions to change one or more of the environmental attributes was set (Table 4-7); second, the *intensity* of application of a specific action type at locations within a watershed was described (Table 4-8).

**Table 4-7.** Adopted Potential of Action Types to Affect Environmental Conditions (%)

| | Environmental Attributes | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Action Type** | **Channel Form** | **Channel Unit Types** | **Substrate** | **Structure** | **Flow** | **Temperature** | **Water Quality** | **Riparian/ Floodplain** |
| Spawning rehabilitation | 95% | 95% | 100% | | | 5% | | |
| Flow augmentation | 10% | 10% | 50% | 5% | 100% | 50% | 25% | 10% |
| Gravel augmentation | 10% | 50% | 75% | 10% | | | | |
| | **Non-Environmental Attributes** | | | | | | | |
| Passage improvements[a] | 90% | | | | | | | |
| Segregation weir[b] | 90% | | | | | | | |
| Floodplain improvements[c] | 50% | | | | | | | |

Note: The percentages in the table reflect the maximum percentage change in recovery potential possible for an environmental or non-environmental attribute due to implementation of a type of action.

[a] Decrease in mortality due to passage conditions.
[b] Separation of fall-run and spring-run Chinook salmon.
[c] Increase in floodplain function.

*Action potential* is the maximum change in recovery potential of each attribute possible due to a type of restoration action (e.g., flow augmentation). Conclusions about action potential were made without regard to feasibility or intent. Each action type was associated with one or more of the environmental and non-environmental attributes, and a conclusion was drawn regarding the potential impact of the action type on the recovery potential associated with each attribute. For example, it is possible that flow augmentation could address up to 100% of the flow limitation characterized in Table 4-5 without regard to the economic, social, or practical feasibility of restoring flow to a pre-development condition. At the same time, flow was associated with several other habitat attributes, such as channel form, but the conclusion was that flow was responsible for only 10% of channel form while the other controls were geology, riparian condition, and so on.

*Action intensity* adjusts the action potential to the reality of implementing an action (e.g., increase flow in Antelope Creek by acquiring water rights). Judgments regarding intensity are based on the extent of the proposed action, for

example the amount of flow that would actually be provided or the miles of riparian forest that would be restored. Intensity reflects the social, economic, and practical considerations that are associated with a specific action. Table 4-8 provides an example of action intensity for three hypothetical proposed actions. These actions would be part of a single overall approach and would collectively contribute to the HET. Action 1 would rehabilitate spawning gravel in 15% of the restoration area and addresses 85% of the passage limitation. Action 2 would augment gravel in 25% of the restoration area, while Action 3 would restore 25% of the normative flow in the restoration area.

**Table 4-8.** Example of Action Intensity for Three Hypothetical Proposed Actions and Their Relationship to Action Types

| | **Intensity of Application of an Action Type in the Restoration Area (%)** | | |
|---|---|---|---|
| **Action Type** | **Action 1** | **Action 2** | **Action 3** |
| Spawning rehabilitation | 15% | -- | -- |
| Flow augmentation | -- | -- | 25% |
| Gravel augmentation | -- | 25% | -- |
| Passage improvements | 85% | | -- |
| Segregation with weir | 0% | -- | -- |
| Floodplain improvements | 5% | -- | -- |

Note: The percentages in the table represent the intensity of application of an action type in the example restoration area for specific actions implemented as part of a proposed approach.

The *expectation* of change in environmental attributes due to a specific proposed action is simply the product of action potential (Table 4-7) and action intensity (Table 4-8). This creates a hypothesis about the expectation of a proposed action to address the habitat limitations in Table 4-4 in terms of the fish recovery potential in Table 4-6. For example, if the action type “flow augmentation” has the potential to address 100% of the flow limitation (Table 4-7) but the proposed action was to restore only 25% of the natural flow regime (Table 4-8), the expectation of change in flow due to the action would be 100% X 25%, or 25% of the flow constraint identified in Table 4-4. The resulting expectations of change in environmental attributes for all action types, as applied to the hypothetical actions in Table 4-8, are shown in Table 4-9.

**Table 4-9.** Expectation of Change in Attributes for Three Hypothetical Proposed Actions (%)

| | Environmental Attributes | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Proposed Action** | **Passage** | **Channel Form** | **Channel Unit Types** | **Substrate** | **Structure** | **Flow** | **Temperature** | **Water Quality** | **Riparian/ Floodplain** |
| Action 1 | 77% | 14% | 14% | 1% | -- | -- | 1% | -- | -- |
| Action 2 | -- | 3% | 13% | 19% | 3% | -- | -- | -- | -- |
| Action 3 | -- | 3% | 3% | 13% | 1% | 25% | 13% | 6% | 3% |
| | | | **Non-Environmental Attributes** | | | | | | |
| Segregation weir | | | 0% | | | | | | |
| Floodplain improvements | | | 2.5% | | | | | | |

Notes: The percentages in the table represent the percentage of expected change in attribute recovery potential from application of the hypothetical actions. Expectation of change in attribute recovery potential due to a proposed action is calculated as the action potential of the action type (Table 4.7) times the action intensity of implementation of a proposed action (Table 4-8).

### 4.2.4.1 Non-Environmental Habitat Actions

Actions that do not directly affect environmental attributes include passage at dams or culverts and use of a segregation weir to separate fall-run and spring-run Chinook salmon. Current passage problems are captured in the watershed diagnosis. The potential for improving passage conditions (Table 4-7) is based on the belief that nearly all passage problems (90%) could be corrected (i.e., a dam could, theoretically, be completely removed). Within the context of the actions considered, a small residual effect (10%) of passage conditions on survival was assumed. The intensity of implementation of passage improvements was specific to individual actions.

Similarly, segregation weirs were assumed to have a maximum possible separation efficiency that is probably less than 100%—there will always be periods and conditions under which fall-run Chinook salmon could get past the weir. The maximum separation efficiency of a segregation weir was assumed to be 90% (Table 4-7).

### 4.2.4.2 Effect of Actions on Juvenile Spring-Run Chinook Salmon

Actions that primarily affect juvenile life stages of salmon do not directly translate into a change in abundance of adult salmon. This is because of the intervening experience of fish between juvenile and adult life stages, and the large mortality that occurs outside the restoration area. Life cycle habitat models

address the conversion of increases in juvenile survival into the change in adult return by computing survival between life stages based on movement along the stream path and the conditions encountered.

The HET contribution procedure does not address the movement of fish between life stages. However, some types of actions, such as restoration of floodplain and off-channel habitats primarily affect juvenile survival and capacity. Without attempting to compute survival between life stages or adult equivalency, the procedure assumes that actions that increase the survival or capacity of the system for the juvenile life stage will increase the overall restoration potential of the system. The treatment effect of juvenile-focused actions, computed from action hypotheses as described above, was applied to increase the adult restoration potential allocated to each environmental attribute (i.e., Table 4-6). For example, it was assumed that floodplain restoration had the potential to address the loss in floodplain function by 50% (Table 4-7). The intensity of the example actions in Table 4-8 was only 5% (an indirect result of flow or channel improvements), resulting in an expectation of change due to floodplain actions of 2.5% (Table 4-9). In the HET contribution procedure, this would increase the restoration potential associated with each action (Table 4-6) by 2.5%, resulting in an increase in adult contribution from the non-floodplain actions.

## 4.2.5 Results

Finally, the contribution of each action to the HET was calculated by taking the expectation of change in each attribute from the actions (Table 4-9) times the spring-run Chinook salmon restoration potential for each attribute (Table 4-6). The result was an estimate of the contribution of each action to the HET.

Table 4-10 shows the results of applying the HET contribution procedure to the three hypothetical proposed actions using the values in the previous tables. Action 1 would produce the greatest contribution to the HET due to the improvement in passage conditions. This result is based on the assumption that there was a significant passage issue in the restoration area (25% mortality), resulting in a large restoration potential associated with passage (313 fish, Table 4-6) and the expectation that measures proposed in Action 1 would address 77% of the passage problem (Table 4-9).

Application of the HET contribution procedure to the three hypothetical proposed actions indicates an increase in adult Chinook salmon abundance (spring-run and fall-run) in the watershed by approximately 400 fish. Assuming that only 65% of the Chinook salmon observed in the restoration area are spring-run Chinook salmon (Section 4.2.3 above), the estimated contribution to the HET would be reduced to 270 spring-run Chinook salmon.

**Table 4-10.** Estimated Contribution to the Habitat Expansion Threshold of Hypothetical Combined Actions (Adult Spring-Run Chinook Salmon)

| | Environmental and Non-Environmental Attributes | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Passage** | **Channel Form** | **Channel Unit Types** | **Substrate** | **Structure** | **Flow** | **Temperature** | **Water Quality** | **Riparian/ Floodplain** | **HET Contribution** |
| Action 1 | 239 | 9 | 9 | 15 | | | 1 | | | 273 |
| Action 2 | | 2 | 8 | 18 | 5 | | | | | 33 |
| Action 3 | | 2 | 2 | 12 | 2 | 73 | 16 | 2 | 2 | 111 |
| | | | | | | | | | **Total** | **415** |

Note: The numbers in the table reflect an estimated increase in adult fish that would result from application of the actions proposed under the hypothetical approach.

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Chapter 5
# Recommended Actions

The Licensees have identified two groupings of habitat expansion and enhancement actions that each meet the goals of the terms and conditions of the HEA: (1) the Lower Yuba River Habitat Expansion Actions (Lower Yuba River Actions); and (2) the Battle Creek, Big Chico Creek, and Antelope Creek Habitat Expansion Actions (Three-Creek Actions). These four watersheds are shown in Figure 5-1.

Each action is briefly described here and more fully described in Chapters 6 through 9. The purpose of this chapter is to present the two recommended actions, state why each is being recommended, and discuss potential issues related to their review under this phase of the HEA. As described in the previous chapters, the Licensees evaluated a large number of potential actions for possible inclusion in this draft HEP and believe that the recommended groups of actions are the best combination of actions to put forward at this time to meet the HET and ensure the success of the HEA in expanding habitat for spring-run Chinook salmon. The Licensees are submitting both of these groups of actions for review and comment by the HEA signatories and other stakeholders, as required by Section 4.1.3 of the HEA. Once the comments are received, the Licensees expect to then select one of the two groups of actions, as may be modified by comments received, and propose this group of actions in the final HEP. NMFS will then determine whether to approve the selected actions in the final HEP, by applying the NMFS Approval Criteria specified in the HEA.

## 5.1 Lower Yuba River Habitat Expansion Actions

Application of the HEA criteria to the List of Viable Actions (as described in Chapter 3) and estimation of these actions' contribution to the HET (as described in Chapter 4) led to identification of a group of actions on the Lower Yuba River that, when combined, would meet the overall goals of the HEA. The individual actions that make up the Lower Yuba River Actions consist of the following:

- rehabilitate spawning habitat in the Englebright Dam reach of the lower Yuba River and augment gravel in lower Deer Creek (a tributary to the Yuba River);
- plan for, and if necessary, install a segregation weir at a location in the 6-mile reach between Englebright Dam and the Highway 20 Bridge; and

- restore juvenile rearing habitat between the Highway 20 Bridge and the downstream extent of the Yuba Goldfields.

Collectively, these actions are referred to as the *Lower Yuba River Actions*. The Lower Yuba River Actions would provide additional habitat between Englebright Dam and the downstream extent of the Yuba Goldfields below Daguerre Point Dam that would support spawning, rearing, and adult holding of spring-run Chinook salmon—in addition to ancillary benefits to steelhead. This group of actions is estimated to expand the habitat sufficiently to accommodate a net increase of approximately 3,450 spring-run Chinook salmon and, furthermore, may lead to establishing a new, independent population.

The estimated contribution to the HET for the Lower Yuba River Actions is the highest of all of the actions considered. These actions also rate favorably on a number of the Evaluation Criteria (as further described in Chapter 6 and shown in Appendix C4) and appear to be the most cost-effective, although a significant amount of effort remains to develop the elements of a final description of the actions. The Licensees propose to continue working with the signatories and active watershed groups who have been considering these actions for a number of years. In particular, outreach with additional stakeholders in the watershed would be necessary before the final HEP can be finalized. Provisions for ongoing operations and maintenance would be negotiated with the stakeholders as appropriate, given that most of the Lower Yuba River Actions would be located on property that is not owned by either Licensee. When the final HEP is approved, the Licensees are confident that—with the support of the signatories and other stakeholders—the Lower Yuba River Actions could be implemented within a reasonable time frame (i.e., within 5 years), with a benefit to spring-run Chinook salmon realized within 10 years. In summary, the Lower Yuba River Actions represent an excellent opportunity to meet the goals of the HEA under its terms and conditions.

Table 5-1 summarizes the attributes assigned to the Lower Yuba River Actions by the Licensees, as well as an evaluation of these actions based on application of the NMFS Approval Criteria specified in the HEA. Approval of the final HEP will be determined by NMFS, after input from the HEA signatories and other stakeholders on this draft HEP, using the Approval Criteria.

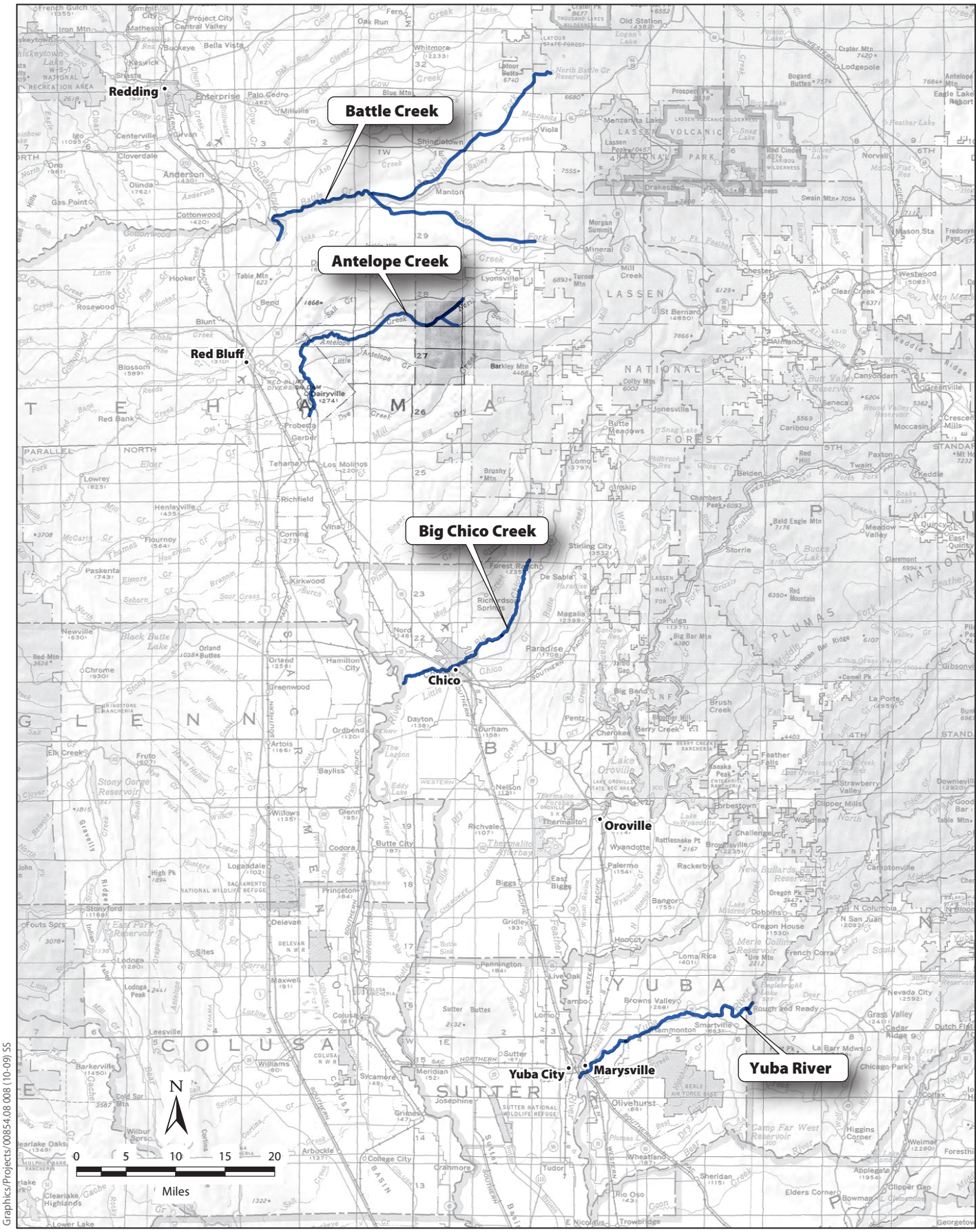


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**Figure 5-1**
**Targeted Watersheds for Habitat Expansion Actions**
**Battle Creek, Antelope Creek, Big Chico Creek, and Yuba River**

**Table 5-1.** Application of NMFS Approval Criteria to Lower Yuba River Habitat Expansion Actions (Lower Yuba River Actions)

| Action Attributes | Lower Yuba River Actions |
|---|---|
| Estimated contribution to the HET | ~3,450 spring-run Chinook salmon[a] |
| Estimated cost | ~$20.6 million[b] |
| **NMFS Approval Criteria Evaluation[c]** | |
| Assures necessary testing, operations and maintenance? | Yes |
| Supports establishing geographically separate self-sustaining population?[d] | Yes |
| Supports segregating spring-run from fall-run?[d] | Yes[e] |
| Eligible? | Yes |
| Expected to be implemented in a reasonable period of time? | Yes |

Note: Lower Yuba River Actions consist of rehabilitating spawning habitat in the Englebright Dam reach of the Lower Yuba River and augmenting gravel in lower Deer Creek (a tributary to Yuba River); planning for and, if necessary, installing a segregation weir at a location in the 6-mile reach between Englebright Dam and the Highway 20 Bridge; and restoring juvenile rearing habitat between the Highway 20 Bridge and the downstream extent of the Yuba Goldfields.

[a] Values reflect the number of adult fish supported by habitat expansion. The estimated contribution of an action to the HET represents an index of the increase in quality and quantity of habitat for spring-run Chinook salmon. Actual results of the actions could differ due to a variety of factors.

[b] A 20% contingency was added to the estimate due to uncertainties in available cost information.

[c] Evaluation applies to the group of three actions, not necessarily each of the individual actions.

[d] Criterion not required for approval.

[e] Segregation may occur naturally or, if necessary, with the installation of a proposed segregation weir.

## 5.1.1 Nexus to Species Recovery Plans

NMFS is developing a plan for recovery of Central Valley spring-run Chinook salmon under the ESA. NMFS has undertaken extensive analysis, participated in public consultations, and in October 2009, released the Public Draft Recovery Plan. Based on these efforts, there is substantial reason to believe that restoration of the Lower Yuba River will be a high priority in the final recovery plan for Central Valley spring-run Chinook salmon and that the actions recommended in the draft HEP for the Lower Yuba River will make a significant contribution to the recovery of spring-run Chinook salmon.

Information developed to date in the federal recovery planning process has indicated that the Lower Yuba River has a high potential to support a viable independent population of spring-run Chinook salmon. Although the area has undergone significant degradation due to a variety of human actions, the Lower Yuba River retains many of the riverine and ecological processes needed to develop and maintain habitat that meets the requirements of spring-run Chinook salmon. For these reasons, the Licensees concluded that restoration of the Lower Yuba River could add to the spatial diversity of the ESU and contribute

significantly to the overall abundance of spring-run Chinook salmon in the Sacramento River basin. The Lower Yuba River Actions have been developed and advanced to the Steering Committee by members of the RMT, are generally supported by the fishery management agencies, and will likely appear as components of the final recovery plan prepared by NMFS.

### 5.1.2 Springboard to Upper Yuba River

The Licensees are aware of NMFS' interest in the reintroduction of spring-run Chinook salmon to the upper Yuba River watershed above Englebright Dam. Such actions were proposed by NMFS during development of this plan and were considered by the Licensees. At this time, the actions—namely developing a trap-and-haul program over Englebright Dam into either the North Yuba River or Middle Yuba River—are in very preliminary stages of discussion and will require substantial development and coordination with numerous stakeholders throughout the Yuba River watershed. While the Licensees are not opposed to this effort, the scale, scope, and timing of such actions do not fit with the criteria (e.g., time to implement actions and realize their benefits) identified in the HEA. In contrast, the proposed Lower Yuba River Actions do provide the potential for creating a viable spring-run Chinook salmon source population in the lower section of the watershed while meeting the criteria identified in the HEA. When passage issues at Englebright Dam are resolved, this new population could be used to initiate a reintroduction program.

### 5.1.3 Stakeholder Support

The lower Yuba River has long been the subject of restoration efforts by federal and state resource agencies, watershed stakeholders, non-governmental organizations, and individuals. During the outreach effort for the HEA, seven questionnaires were received for habitat expansion actions in the lower Yuba River (Appendix F1), more than for any other watershed.

In April 2005, the Lower Yuba River Accord (Yuba Accord) was signed. The Yuba Accord is an agreement reached among 17 stakeholders in the Yuba River watershed to operate the Yuba River Development Project, a hydroelectric development owned and operated by the Yuba County Water Agency (YCWA) in the upper watershed. The Yuba Accord enables YCWA to reoperate its project for hydropower, irrigation, flood control, recreation, and fisheries benefits. The benefits to fisheries include improved water temperatures and flow characteristics that more closely mimic the natural riverine processes.

Under the Yuba Accord, the RMT was formed. The RMT, which includes representatives of the signatories to the Yuba Accord, has been monitoring and evaluating the effectiveness of the Yuba Accord on the fisheries resources of the lower Yuba River. The RMT responsibilities will continue through 2016, when the Yuba Accord expires. The Licensees have been working with members of

the RMT to develop the Lower Yuba River Actions for the HEA. Members of the RMT have expressed their support for these actions. Their detailed evaluation of the Lower Yuba River Actions is included in Appendix G.

### 5.1.4 Eligibility

The HEA allows for a variety of actions to be considered eligible for inclusion in the HEP. Actions identified in other venues, including unfunded actions, are acceptable for consideration, provided implementation results in a net expansion of habitat over any existing requirements and commitments. These are defined in Section 3.2 of the HEA and may include, but are not limited to, legal or regulatory requirements subject to a binding order, action by an agency or court, relicensing proceedings, or existing biological opinions.

On November 21, 2007, NMFS issued a biological opinion to the Corps to address the effects of operations on spring-run Chinook salmon (and other species) at both Englebright and Daguerre Point Dams. In the biological opinion, NMFS issued an incidental take statement with a number of Reasonable and Prudent Measures, including the following:

1. *The Corps shall develop and implement a long-term gravel augmentation program to restore quality spawning habitat below Englebright Dam.*

    A) *The Corps shall utilize the information obtained from the pilot gravel injection project to develop and commence implementation of a long-term gravel augmentation program within three years of the issuance of this biological opinion.*

In November 2007, a pilot gravel injection project was undertaken in the Narrows reach just below Englebright Dam. Monitoring and evaluation are currently underway, but preliminary results indicate that injection of gravel alone may create only pockets of suitable spawning habitat. The large-scale channel rehabilitation, as proposed in the Lower Yuba River Actions for the Englebright Dam reach, would be additional and complementary to the gravel augmentation program required of the Corps by NMFS' biological opinion. Ideally, the channel rehabilitation under the HEA would be completed before establishing a long-term gravel augmentation program, to allow for an expansive increase in suitable spawning habitat. Once the Lower Yuba River Actions are completed, the long-term gravel augmentation program required of the Corps under the NMFS' biological opinion for long-term gravel augmentation would provide for long-term maintenance of the habitat created by the Lower Yuba River Actions.

## 5.1.5 Options to Segregation Weir

The Lower Yuba River Actions proposed by the Licensees would expand spawning habitat in the Englebright Dam reach of the lower Yuba River and lower Deer Creek. Although there is some evidence that natural segregation between spring-run and fall-run Chinook salmon occurs in this reach, thus eliminating or reducing the spawning overlap of the two runs, this cannot be determined until the expanded spawning habitat is provided in the reach. To ensure that segregation of spring-run and fall-run Chinook salmon occurs and that spawning habitat is provided for spring-run Chinook salmon, the Licensees have included a proposal to construct and operate a seasonal segregation weir at a location in the 6-mile reach between Englebright Dam and the Highway 20 Bridge. Using an adaptive management approach, the weir would not be constructed until there was evidence of its necessity and until it use was supported by the resource agencies and other stakeholders. The weir would allow for mechanical separation of the two runs by run timing. The weir would be operated to permit passage of Chinook salmon during the primary spring-run Chinook salmon migration period and to prevent passage of Chinook salmon during the primary fall-run migration period.

If this uncertainty is found unacceptable under the terms of the HEA, the following solution is offered as an alternative to the segregation weir action:

> Eliminate the segregation weir from the Lower Yuba River Actions and select one of the following actions that would contribute to the HET and provide habitat expansion or enhancement under a more immediate and certain timeframe:
>
> - Antelope Creek Habitat Expansion Action – construct a bridge at Paynes Crossing on Antelope Creek, or
> - Big Chico Creek Habitat Expansion Action – rehabilitate the Iron Canyon Fish Ladder on Big Chico Creek.

The preceding actions are described in further detail in Chapter 7, “Antelope Creek Habitat Expansion Action,” and Chapter 8, “Big Chico Creek Habitat Expansion Action,” respectively.

Table 5-2 summarizes the attributes assigned to the actions described above, based on application of the NMFS Approval Criteria provided in the HEA.

**Table 5-2.** Application of NMFS Approval Criteria to Antelope Creek and Big Chico Creek Habitat Expansion Actions

| Action Attributes | Construct Bridge at Paynes Crossing on Antelope Creek | Rehabilitate Iron Canyon Fish Ladder on Big Chico Creek |
|---|---|---|
| Estimated contribution to the Habitat Expansion Threshold | ~250 spring-run Chinook salmon[a] | ~500 spring-run Chinook salmon[a] |
| Estimated cost | $1.0 million | $2.7 million |
| **NMFS Approval Criteria Evaluation** | | |
| Assures necessary testing, operations and maintenance? | Yes | Yes |
| Supports establishing geographically separate self-sustaining population?[b] | No | No |
| Supports segregating spring-run from fall-run?[b] | Yes | Yes |
| Eligible? | Yes | Yes |
| Expected to be implemented in a reasonable period of time? | Yes | Yes |

Note: If the uncertainty of the segregation weir as a component of the Lower Yuba River Actions is found unacceptable under the terms of the HEA, implementation of either the Antelope Creek Action (construct a bridge at Paynes Crossing) or the Big Chico Creek Action (rehabilitate the Iron Canyon Fish Ladder) is offered in lieu of the segregation weir. The estimated cost for the segregation weir is $300,000 capital cost and $52,000 annual operations and maintenance (a total cost of $2.6 million for 50 years).

[a] Values reflect the number of adult fish supported by habitat expansion. The estimated contribution of an action to the HET represents an index of the increase in quality and quantity of habitat for spring-run Chinook salmon. Actual results of the actions could differ due to a variety of factors.

[b] Criterion not required for NMFS approval.

## 5.1.6 Summary of Recommendation for Lower Yuba River Actions

The Licensees believe that the Lower Yuba River Actions as proposed with the segregation weir, or with either one of the actions on Antelope Creek or Big Chico Creek, would meet the goal of the HEA under its terms and conditions and support inclusion of the Lower Yuba River Actions in the final HEP. The evaluation of the Lower Yuba River Actions relative to the HEA Evaluation and Selection Criteria is discussed in Chapter 6. Further effort is required to more fully describe the Lower Yuba River Actions, in terms of all of the elements of Section 4.1.3 of the HEA, before its inclusion in the final HEP; however, work with some of the watershed stakeholders in developing this draft HEP indicate that there is broad support for its implementation.

# 5.2 Battle Creek, Big Chico Creek, and Antelope Creek Habitat Expansion Actions

The Licensees identified another group of actions that, when combined, would meet the goals of the HEA. This group of actions consists of habitat expansion and enhancement actions in three watersheds: Battle Creek, Big Chico Creek, and Antelope Creek. Specifically, the individual actions consist of the following:

- Battle Creek Habitat Expansion Actions, provide partial funding for implementation of Phase 2 of the Battle Creek Salmon and Steelhead Restoration Project;
- Antelope Creek Habitat Expansion Action, construct a bridge at Paynes Crossing on Antelope Creek; and
- Big Chico Creek Habitat Expansion Action, rehabilitate the Iron Canyon Fish Ladder on Big Chico Creek.

Collectively, these three actions are referred to as the *Three-Creek Actions*. Each of the actions is described more fully in Chapters 7, 8, and 9.

Overall, the Three-Creek Actions are estimated to provide a net increase in habitat to support approximately 2,350 spring-run Chinook salmon, in addition to providing ancillary benefits to steelhead. Individually, the actions rate favorably on most of the Evaluation and Selection Criteria. The Three-Creek Actions have the potential to provide habitat expansion and enhancement in a more immediate and certain timeframe than the Lower Yuba River Actions, as each of the individual actions only need funding to begin implementation. For all three actions, feasibility and design studies are complete, permitting phases are underway or complete, and implementation partners are established. The three actions are essentially "shovel-ready." As such, they have received extensive vetting; they also have support from a broad coalition of governmental, non-governmental, public, and private stakeholders in their respective watersheds. Once constructed, operations and maintenance could be performed by implementation partners already identified and, in the case of the actions on Battle Creek and Big Chico Creek, using separate operations and maintenance funds already committed by PG&E and DFG, respectively. These actions leverage existing efforts and funds expended by others and have the potential to provide additional habitat many years sooner than the Lower Yuba River Actions.

Table 5-3 summarizes the attributes assigned to the Three-Creek Actions by the Licensees, as well as an evaluation of the actions based on applying the NMFS Approval Criteria specified in the HEA. Approval of the final HEP will be determined by NMFS, after input from the HEA signatories and other stakeholders on this draft HEP, using the Approval Criteria.

**Table 5-3.** Application of NMFS Approval Criteria to Battle Creek, Big Chico Creek, and Antelope Creek Habitat Expansion Actions (Three-Creek Actions)

| Action Attributes | Three-Creek Actions |
|---|---|
| Estimated contribution to Habitat Expansion Threshold | ~2,350 spring-run Chinook salmon[a, b] |
| Estimated cost | $20.6 million[c] |
| **NMFS Approval Criteria Evaluation[d]** | |
| Assures necessary testing, operations and maintenance? | Yes |
| Supports establishing geographically separate self-sustaining population?[e] | Yes |
| Supports segregating spring-run from fall-run?[e] | Yes |
| Eligible? | Yes |
| Expected to be implemented in a reasonable period of time? | Yes |

Note: Battle Creek, Big Chico Creek, and Antelope Creek Habitat Expansion Actions (Three-Creek Actions) consist of partial funding for implementation of Phase 2 of the Battle Creek Salmon and Steelhead Restoration Project, construction of a bridge at Paynes Crossing on Antelope Creek, and rehabilitation of the Iron Canyon fish ladder on Big Chico Creek

[a] Values reflect the number of adult fish supported by habitat expansion. The estimated contribution of an action to the Habitat Expansion Threshold (HET) represents an index of the increase in quality and quantity of habitat for spring-run Chinook salmon. Actual results of the actions could differ due to a variety of factors.

[b] Additional funding partners would need to be identified in order to meet this estimated contribution to the HET.

[c] Cost estimate includes partial funding for implementation of Phase 2 of the Battle Creek Salmon and Steelhead Restoration Project, and full funding for construction of Antelope and Big Chico Creek actions, as well as provisions for operations and maintenance not already committed to by others.

[d] Evaluation applies to the group of three actions, not necessarily each of the individual actions.

[e] Criterion not required for NMFS approval.

## 5.2.1 Battle Creek Habitat Expansion Actions

The Battle Creek Salmon and Steelhead Restoration Project (Battle Creek Restoration Project) is the result of a 1999 Memorandum of Understanding (MOU) among the U.S. Department of the Interior, Bureau of Reclamation (Reclamation), USFWS, NMFS, DFG, and PG&E. The Battle Creek Restoration Project presents an opportunity to reestablish approximately 42 miles of prime salmon and steelhead habitat on Battle Creek, plus an additional 6 miles of habitat on its tributaries. Restoration would be accomplished primarily through modification of the existing Battle Creek Hydroelectric Project (owned and operated by PG&E) facilities and operations, including increased instream flow releases. The Battle Creek Restoration Project is being implemented in three phases, each of which has independent ecological and environmental benefits. Phases 1A and 1B have been funded and are currently being implemented. Phase 2 has not been funded and therefore cannot be implemented.

The three phases of the Battle Creek Restoration Project are described as follows. Phase 1A consists of fish passage improvements on the North Fork of Battle Creek, primarily installing fish screens and ladders, removing a dam, and increasing instream flows. Phase 1B consists of improvements on the lower South Fork of Battle Creek, primarily installing a tailrace connector and bypass at one of the powerhouses. Phase 2 would consist of additional fish passage and habitat improvements on the South Fork of Battle Creek, including removing four dams, decommissioning a canal, installing fish screens and ladders on the remaining dam, installing an additional tailrace connector, and increasing instream flows. Additional details on the Battle Creek Habitat Expansion Actions are provided in Chapter 9.

#### 5.2.1.1 Rationale for Selection

As described in Chapter 9, the Battle Creek Habitat Expansion Actions (Battle Creek Actions) offer the second highest contribution to the HET in a single watershed after the Lower Yuba River Actions. The Battle Creek Actions are estimated to expand habitat sufficiently to accommodate a net increase of approximately 1,600 spring-run Chinook salmon. Along with implementation of the remainder of the Battle Creek Restoration Project, the Battle Creek Actions would provide prime habitat for winter-run Chinook salmon and steelhead, in addition to spring-run Chinook salmon, especially during drought years. The actions rate favorably on a number of the Evaluation Criteria, as presented in Appendix C4.

Based on current cost estimates provided by Reclamation, it is not necessarily one of the most cost-effective actions identified for spring-run Chinook salmon; however, its costs are based on well-defined actions described in the MOU, which provides certainty regarding the costs of specific restoration components. The O&M costs, including the increased instream flows post construction, would be borne by PG&E under the terms of the MOU and would not require funding under the HEA. Separate funding provisions also have been made for ongoing adaptive management that would ensure the continued success of the restoration effort.

The MOU signatories have been successful in securing funds for Phase 1A and Phase 1B using a mix of federal, state, and private funds. Funding has not been secured for Phase 2, however, and at this time no entity is required or committed to provide secure funding. Success in funding Phases 1A and 1B suggests that a substantial contribution from the HEA toward implementing Phase 2 may help secure funding for Phase 2 in its entirety. At present, DFG has identified approximately $12 million that may be obligated if additional funds can be identified to complete Phase 2. It is also likely that the cost estimate prepared by Reclamation for the Battle Creek Restoration Project will be revised downward to reflect the more favorable current economic conditions, compared to those in 2005 when the cost estimates were last fully evaluated. Once funding has been identified for all of Phase 2, the Licensees are confident that, with the support of the stakeholders, Phase 2 could be implemented in a reasonable time frame (i.e.,

estimated to occur within 5 years), with a benefit to spring-run Chinook salmon realized within 10 years. In summary, the Battle Creek Actions represent an opportunity to significantly contribute to the goals of the HEA under its terms and conditions.

### 5.2.1.2 Eligibility

As noted, the HEA allows for a variety of actions to be considered eligible for inclusion in the HEP. Actions identified in other venues, including unfunded actions, are acceptable for consideration, provided their implementation results in a net expansion of habitat over any existing requirements and commitments. These are defined in Section 3.2 of the HEA and may include, but are not limited to, legal or regulatory requirements subject to a binding order, action by an agency or court, relicensing proceedings, or biological opinions.

The Battle Creek Restoration Project is a cooperative effort by the signatories of a 1999 Memorandum of Understanding (MOU). As stated in Section 1.4 of the MOU, it is a voluntary partnership between the state and federal agencies, including NMFS; third-party donors; and PG&E. Currently, FERC has issued an Order to Construct Phase 1A of the Battle Creek Restoration Project. Submittal of a license amendment application is imminent for Phase 1B since funding has been secured through the American Recovery and Reinvestment Act of 2009. A license amendment application will not be submitted for Phase 2 of the Battle Creek Restoration Project until funding is secured for that phase. Section 16.0 of the MOU provides for its termination in a number of ways, including lack of funding sources. Based on the terms of the MOU, Phase 2 will not be implemented unless and until funding is secured. At this time, only approximately $12 million of the estimated $47 million cost of Phase 2 has been identified but has not been secured.

NMFS recognizes the value of improving spawning access to Battle Creek, as evidenced in its partnership in the MOU. Lindley et al. (2007) states that "restoring flows and habitat…in Battle Creek…[has] the potential to significantly improve the status of affected ESUs, but achieving recovery may require access to additional historically-utilized spawning areas that are currently blocked by dams." In addition, NMFS issued a biological opinion on the *Long-Term Central Valley Project and State Water Project Operation, Criteria, and Plan* (OCAP) on June 4, 2009. The OCAP biological opinion states the following action to be taken with regard to Battle Creek:

> ***Action I.2.6. Restore Battle Creek for Winter-Run, Spring-Run, and CV Steelhead***
>
> ***Objective:*** *To partially compensate for unavoidable adverse effects of project operations by restoring winter-run and spring-run to the Battle Creek watershed. A second population of winter-run would reduce the risk of extinction of the species from lost resiliency and increased vulnerability to catastrophic events.*

> ***Description of Action:*** *Reclamation shall direct discretionary funds to implement the Battle Creek Salmon and Steelhead Restoration Project. Phase 1A funding is currently allocated through various partners and scheduled to commence in Summer 2009 (Reclamation 2008c). DWR shall direct discretionary funds for Phase 1B and Phase 2, consistent with the proposed amended Delta Fish Agreement by December 31 of each year, Reclamation and DWR will submit a written report to NMFS on the status of the project, including phases completed, funds expended, effectiveness of project actions, additional actions planned (including a schedule for further actions), and additional funds needed. The Battle Creek Salmon and Steelhead Restoration Project shall be completed no later than 2019.*

As stated, the NMFS OCAP biological opinion Action I.2.6 requires Reclamation and DWR to direct discretionary funds to the Battle Creek Restoration Project. However, this statement does not ensure that such discretionary funds will be available, does not provide an alternative funding mechanism in the absence of such funds, as is presently the case, and ultimately does not secure funding for Phase 2. The biological opinion also does not provide a means for completing the project before 2019.

Table 5-4 summarizes the attributes assigned to the Battle Creek Actions by the Licensees as well as an evaluation of the actions applying the NMFS Approval Criteria provided in the HEA. Approval of the final HEP will be determined by NMFS, with input from the HEA signatories and other stakeholders on this draft HEP, using the Approval Criteria.

**Table 5-4.** Application of NMFS Approval Criteria to the Battle Creek Habitat Expansion Actions

| **Action Attributes** | **Partial Funding – Battle Creek Phase 2** |
|---|---|
| Estimated contribution to Habitat Expansion Threshold | ~1,600 spring-run Chinook salmon[a] |
| HEA funding contribution to Phase 2 | $16.9 million |
| Cost Estimate for total Phase 2 | $46.3 million[a] |
| **NMFS Approval Criteria Evaluation** | |
| Assures necessary testing, operations and maintenance? | Yes |
| Supports establishing geographically separate self-sustaining population?[b] | Yes |
| Supports segregating spring-run from fall-run?[b] | Yes |
| Eligible? | Yes |
| Expected to be implemented in a reasonable period of time? | Yes |

[a] Funding partners would need to be identified to meet the estimated contribution to the HET.
[b] Criterion not required for NMFS approval.

### 5.2.2 Big Chico Creek and Antelope Creek Actions

The actions in Antelope and Big Chico Creeks were added to the Battle Creek Actions to increase the estimated contribution to the HET. Individually, they represent relatively "shovel-ready," cost-effective, and well supported actions. In addition to these actions, a number of restoration efforts are ongoing by others in the watersheds. The individual evaluations of these actions with regard to the NMFS Approval Criteria are provided in Table 5-2. Further rationale for their inclusion in the draft HEP is provided in Chapters 7 and 8.

### 5.2.1 Summary of Recommendation for Three-Creek Actions

In conclusion, the Three-Creek Actions would meet the goals of the HEA under its terms and conditions, and the Licensees support its inclusion in the final HEP. Further evaluation of its components relative to the Evaluation and Selection Criteria is given in Chapters 7, 8, and 9. Further effort is required to more fully describe the action in terms of all of the elements in Section 4.1.3 of the HEA before its inclusion in the final HEP. However, extensive work has been completed by the individual watershed stakeholders.

Prior to submitting a final HEP, the Licensees will consult with the signatories of the Battle Creek Restoration Project MOU concerning additional partners for full funding of Phase 2. After the remaining funds needed to complete Phase 2 have been secured, the Licensees would provide up to a $16.9 million contribution pursuant to the cost sharing provisions agreed to by DWR and PG&E for implementation of the HEA. Consistent with those provisions, PG&E will be the performing party for construction of capital improvements associated with the $16.9 million contribution. In order to provide consistency and continuity in construction of capital improvements for all of Phase 2, the Licensees favor PG&E's role as the performing party for construction of all Phase 2 capital improvements. The Licensees likewise would continue to consult with the stakeholders for the Big Chico and Antelope Creek Actions to determine the most efficient way to ensure that construction can begin and that long-term O&M are provided for the structures that would result from these actions.

## 5.3 Reference

Lindley, S. T. and others. 2007. Framework for assessing viability of threatened and endangered Chinook salmon and steelhead in the Sacramento-San Joaquin Basin. Page 4 *in* San Francisco Estuary and Watershed Science [online serial]. San Francisco Estuary and Watershed Science [online].

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Chapter 6

# Lower Yuba River Habitat Expansion Actions

Lower Yuba River photo credit:
by Dr. Gregory Pasternack, University of California at Davis, 2006.

## 6.1 Description of Habitat Expansion Actions

### 6.1.1 Background

The Yuba River historically was a major contributor of spring-run Chinook salmon to the Sacramento River system. However, like most of the major tributaries to the Sacramento River, the habitat potential of the Yuba River has been considerably diminished, by extreme geomorphic alteration resulting from hydraulic and dredge mining for gold and then by construction of dams that blocked access to major spring-run Chinook salmon spawning areas.

Construction of Englebright Dam at river mile (RM) 24 blocked access to most of the Yuba River system. Historically, spring-run Chinook salmon production areas were in the upper stream reaches, and spring-run Chinook salmon did not spawn in the lower river reaches that constitute the currently accessible portion of the Yuba River. In part, this was because conditions below the site of Englebright Dam historically were not conducive to production of spring-run Chinook; the river was too warm in fall. However, New Bullards Bar Dam on the North Yuba River now releases cold water through much of the summer and fall from its very deep reservoir. Consequently, water temperatures below Englebright Dam are now suitable for spring-run Chinook. Currently, both fall-run and spring-run Chinook salmon spawn below Englebright Dam, although the fall-run are far more abundant.

The primary intent of the Lower Yuba Habitat Expansion Actions (Lower Yuba River Actions) is to provide conditions that would encourage development of an independent spring-run Chinook salmon population and provide ancillary benefits to steelhead. Development of conditions suitable for healthy populations of spring-run Chinook salmon and steelhead can be expected to provide benefits to other native species.

The Lower Yuba River Actions also would substantially contribute to restoration of normative riverine processes in the lower Yuba River. These normative processes have been severely impacted due to the legacy of historical hydrologic mining in the Yuba River watershed, in addition to construction of upstream dams including Englebright Dam. The Lower Yuba River Actions would address channel degradation issues and enhance aquatic habitat in the lower Yuba River, primarily for the benefit of spring-run Chinook salmon.

Individual actions were proposed to the Steering Committee by the South Yuba River Citizens League (SYRCL), Friends of Deer Creek, USFWS AFRP, and DFG. Three individually proposed actions were combined in the Lower Yuba River Actions. During development of the Lower Yuba River Actions, the Licensee consulted with the RMT and DFG to refine and focus the actions. Members of the RMT have expressed their support for the actions. Their detailed evaluation of the Lower Yuba River Actions is included in Appendix G.

## 6.1.2 Location

Lower Yuba River Actions are on the lower Yuba River between Englebright Dam (RM 24) and the downstream extent of the Yuba Goldfields below Daguerre Point Dam (RM 12) (Figure 6-1).

## 6.1.3 Purpose

Lower Yuba River Actions are intended to provide the habitat conditions below Englebright Dam on the Yuba River necessary to promote development of an independent population of spring-run Chinook salmon and provide ancillary benefits to steelhead. These actions also would enhance separation of spring-run and fall-run Chinook salmon in the lower Yuba River by increasing the amount of habitat in the lower Yuba River with characteristics more typical of spring-run Chinook salmon than of fall-run Chinook. Achievement of these goals would meet the requirements under the HEA, including the contribution to the HET.

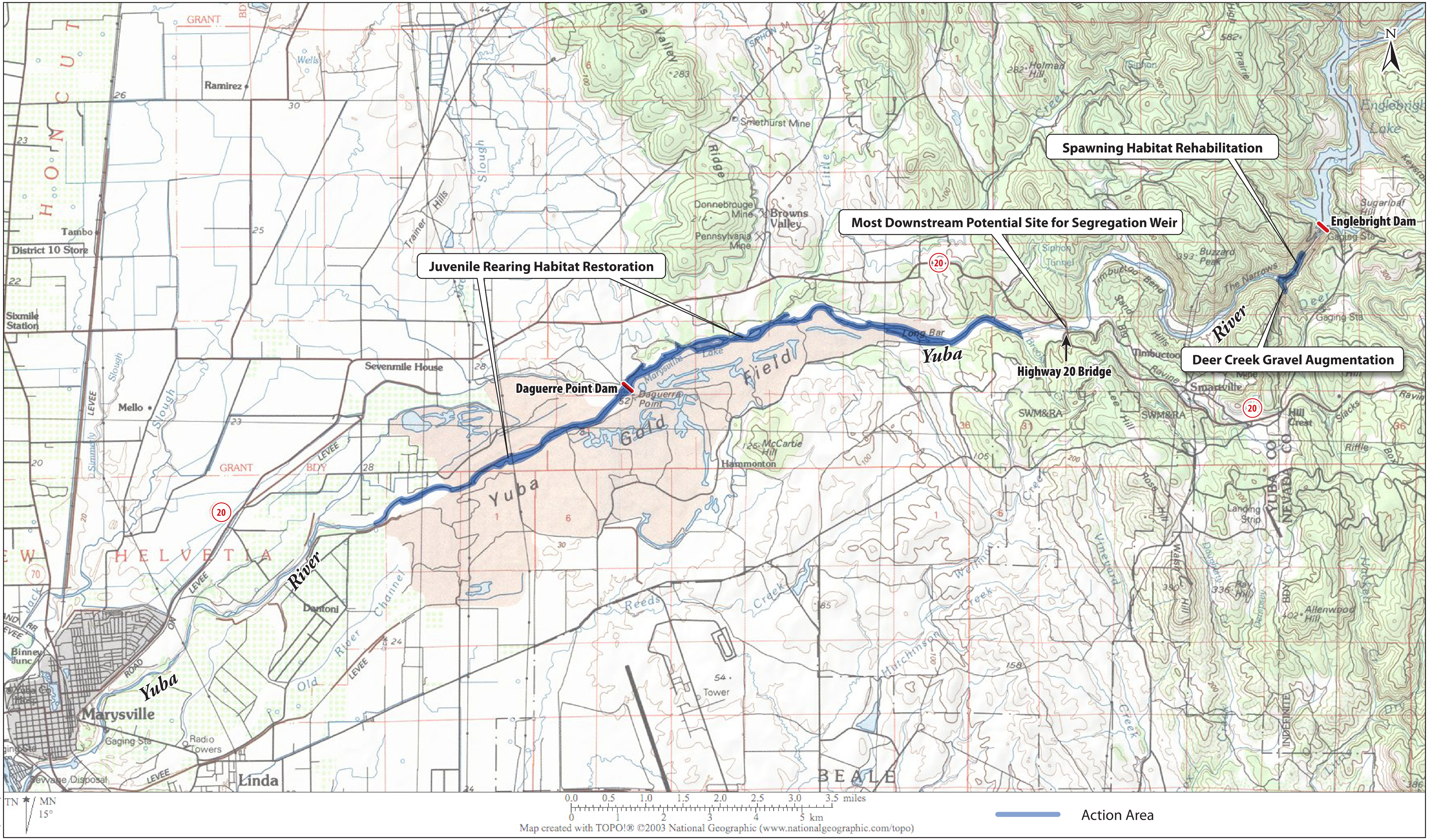


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**Figure 6-1**
**Lower Yuba River Habitat Expansion Actions**

## 6.1.4 Recommended Actions

Lower Yuba River Actions integrate three individual actions. Integration of these actions is important because the actions benefit from each other. These integrated habitat expansion actions provide greater benefits relative to the HEA criteria than any of the individual actions.

The three actions include:

- rehabilitate spawning habitat in the Englebright Dam reach of the lower Yuba River and augment gravel in lower Deer Creek (a tributary to Yuba River) (described in Section 6.4 below);
- plan for, and if necessary, install a segregation weir at a location in the 6-mile reach between Englebright Dam and the Highway 20 Bridge (described in Section 6.5 below); and
- restore juvenile rearing habitat between the Highway 20 Bridge and the downstream extent of the Yuba Goldfields (described in Section 6.6 below).

The locations of these actions within the lower Yuba River watershed are shown in Figure 6-1.

The combined actions would promote increased production of spring-run Chinook salmon and steelhead by increasing the quantity and quality of spawning and rearing habitat. The HEA directs that actions should also encourage separation of spring-run and fall-run Chinook salmon. The Licensees concluded that this goal can be achieved by increasing the amount of habitat in the lower Yuba River with characteristics more typical of spring-run Chinook salmon than fall-run Chinook. This would be accomplished by enhancing conditions in the upper, higher gradient Englebright Dam reach of the river. To prevent the potential for redd superimposition in this reach, a segregation weir at Timbuctoo Bend is included as an optional action to allow for mechanical separation of the two runs. The inclusion of the segregation weir considerably enhances the value of the actions listed above relative to the HEA criteria. However, consultation with DFG and the RMT has indicated that a weir to separate spring-run and fall-run Chinook in a way that benefits spring-run Chinook salmon may not be supported at this time. Ongoing migration and genetic studies would provide information on the future value or need for the segregation weir.

## 6.1.5 Sources

Representatives of the following organizations were helpful in identifying and defining the Lower Yuba River Actions through completed HEA questionnaires (Appendix F1), meetings, and personal communications: USFWS, Friends of Deer Creek, YCWA, Pacific State Marine Fisheries Commission, DFG, UC Davis (Dr. Greg Pasternack), SYRCL, and the RMT.

# 6.2 Context for Action

## 6.2.1 Description of the Watershed

The following description of the Yuba River watershed and the lower Yuba River draws largely on descriptions by YCWA et al. (2007) and SYRCL (2009), with other sources noted. The Yuba River basin drains approximately 1,339 square miles of the western Sierra Nevada, including portions of Sierra, Placer, Yuba, and Nevada Counties. The Yuba River is a tributary of the Feather River, which is, in turn, a tributary of the Sacramento River. The primary watercourses of the upper Yuba River watershed are the South, Middle, and North Yuba Rivers, which flow into Englebright Reservoir. The average annual unimpaired flow of the Yuba River at Smartville is 2.45 million acre-feet (MAF); however, a significant portion of this water is diverted out of the watershed and is not available to the lower Yuba River. The annual unimpaired flow has ranged from a maximum of about 4.9 MAF in 1986 to a minimum of about 370 thousand acre-feet (TAF) in 1977.

The lower Yuba River is approximately 24 miles long and stretches from Englebright Dam downstream to the confluence with the Feather River at Marysville. Englebright Dam is an impassable barrier to anadromous fish. The dam was constructed in 1941 to control mining debris and provide flood control. Construction of New Bullards Bar Dam, on the North Yuba River, in 1969 allowed Englebright Dam operations to switch from flood control to provision of water for hydroelectricity, irrigation, and fisheries (NMFS 2007). The short reach immediately below Englebright Dam to the Deer Creek confluence has been greatly altered by mining debris and dam operations, and is lacking gravel. Below the confluence with Deer Creek, the Narrows is a step-pool reach with significant amounts of alluvial sediment and significant rapids (Pasternack 2008).

Downstream of the Narrows, the lower Yuba River consists of alternating runs, pools, and riffles. The river flows through a valley moderately confined by the Sierra foothills until it reaches Long Bar (RM 16), where it enters an alluvial valley and flows to Daguerre Point Dam (Kozlowski 2004). This dam, located approximately 12 miles downstream of Englebright Dam, was constructed in 1906 to provide flood control and to trap mining debris (Kozlowski 2004). The dam's purpose was later modified to include diversion of water for irrigation; the entire reservoir behind the dam is presently filled with hydraulic mine waste and sediments, and has no water storage capacity (NMFS 2007).

Daguerre Point Dam is 25 feet tall, with fish ladders on either side that allow passage of some migratory species (Kozlowski 2004). The fish ladders have suboptimal design, and sheet flow across the dam spillway may obscure attraction to the ladder entrances, particularly during high flows (NMFS 2007). The reach from Long Bar to RM 8 is within the Yuba Goldfields and is confined by dredger tailings and low gravel bars. Below the Goldfields to the confluence with the Feather River, the river banks are frequently armored with boulder and broken concrete (Kozlowski 2004).

## 6.2.2 Status of Spring-Run Chinook Salmon and Steelhead Runs

### 6.2.2.1 Spring-Run Chinook Salmon

Little information has been published regarding the status of spring-run Chinook salmon in the lower Yuba River. Historical numbers are likely to have been considerably higher than observed today but were probably greatly diminished by gold mining, construction of impassable dams, and water diversions (Yoshiyama et al. 2001). The following account is taken from the NMFS (2007) biological opinion provided to the Corps on the effects of operations of Englebright and Daguerre Point Dams:

> There is limited information on the current population size of spring-run Chinook salmon in the lower Yuba River. Before 2001, when DFG conducted a study to quantify the number of adult spring-run Chinook salmon immigrating into the Yuba River by trapping fish in the fish ladder at Daguerre Point Dam, there was almost no specific information on the run timing and size of the population in the Yuba River. In the 2001 DFG study, which involved limited sampling of fish ascending the north ladder, a total of 108 adult Chinook salmon were estimated to have passed the dam between the dam between March 1, 2001, and July 31, 2001 (DFG 2002c).
>
> Spawning and carcass surveys conducted by DFG and private consultants funded by the YCWA have likewise detected the persistence of spring-run Chinook salmon in the Yuba River, although none of these reports provided estimates specifically for spring-run Chinook salmon.
>
> Infrared and videographic sampling on both ladders at Daguerre Point Dam since 2003 has provided more robust estimates of spring-run Chinook salmon numbers migrating into the Yuba River. However, these estimates should be considered as *minimum* numbers, as periodic problems with the sampling equipment have caused periods when fish ascending the ladders were not counted. In years when these sorts of gaps in data occurred during the spring-run migration period, it is likely that some migrating adults were not counted, and the true numbers may be higher than those reported below (DFG unpublished data)…The detection of adipose fin clips on some of these fish indicates that they were hatchery strays, most likely from the Feather River Hatchery. The short time period in which this device has been in operation, coupled with the three to four year life cycle of these fish make it difficult to determine decisive trends in the spring run population. While the recent data from 2006 and 2007 indicates a reduction in total abundance, passage in May (the primary spring-run migration month) of 2007, was the highest detected in that month since the device was installed.
>
> In general, the current data indicate that adult escapement of spring-run Chinook salmon is relatively low and fluctuating, and has been greatly reduced from estimated historic levels.

The recent total abundance of adult spring-run Chinook salmon in the lower Yuba River ranged from 214 in 2006 to 1,250 in 2003, based on the infrared and videographic sampling described by NMFS (2007).

#### 6.2.2.2 Steelhead

As with spring-run Chinook salmon, there is little information on the status of steelhead in the lower Yuba River. The historical population size was likely to have been considerably greater than recent abundance estimates. The following account is by NMFS (2007):

> DFG estimated a spawning population of only about 200 fish annually prior to 1969. During the 1970s, DFG annually stocked hatchery steelhead from Coleman National Fish Hatchery into the lower Yuba River, and by 1975 estimated a run size of about 2000 fish (DFG 1991). DFG stopped stocking steelhead in the lower Yuba River in 1979, and currently manages the river to protect natural steelhead through strict "catch-and-release" fishing regulations.
>
> Infrared and videographic sampling on both ladders at Daguerre Point Dam since 2003 has provided estimates of steelhead numbers migrating up the Yuba River. However, these estimates should be considered as *minimum* numbers, as periodic problems with the sampling equipment have caused periods when fish ascending the ladders were not counted.

The total abundance of adult steelhead estimated to have passed Daguerre Point Dam from 2003 to 2007 ranged from 150 fish in 2006 to 762 fish in 2004 (NMFS 2007).

### 6.2.3 Limiting Factors

The primary factors identified as constraints to establishing a viable, independent spring-run Chinook salmon population in the lower Yuba River include:

- lack of suitable spawning habitat in the Englebright Dam reach (Englebright Dam to Deer Creek),
- lack of spatial or temporal segregation of spawning spring-run and fall-run Chinook salmon,
- straying of hatchery fish to the lower Yuba River,
- fish passage impediments at Daguerre Point Dam, and
- lack of habitat complexity and diversity in the Yuba Goldfields area below the Highway 20 Bridge.

These factors are discussed below.

#### 6.2.3.1 Lack of Suitable Spawning Habitat

Seasonal flows, water temperatures, and channel characteristics in the lower Yuba River between Englebright Dam and Daguerre Point Dam are generally suitable for holding, spawning, and rearing of spring-run Chinook salmon based

on their known life history and habitat requirements. The suitability of the river for summer holding (June through September) and late summer-early fall spawning (August through October) generally increases in an upstream direction, with the highest quality habitat in the reach between the Narrows (RM 22) and the Highway 20 Bridge (RM 18). This reach is characterized by a series of deep, bedrock-formed pools and large spawning riffles that currently support high densities of fall-run Chinook spawners. Water temperatures in this reach typically reach suitable levels for spawning by early to late September.

Spawning by the majority of fall-run and virtually all spring-run Chinook salmon and steelhead in the lower Yuba River occurs between Daguerre Point Dam and the Narrows. Early-arriving adults (i.e., phenotypic spring-run) tend to spawn farther upstream than later arrivals (i.e., phenotypic fall-run). Little spawning habitat now exists in the 2-mile reach extending from the Narrows canyon upstream to Englebright Dam because of its steep gradient, lack of sediment supply, and armoring by rock debris (Pasternack 2008). This reach has received considerable attention for spawning habitat rehabilitation specifically aimed at spring-run Chinook salmon because of the presence of high-quality holding habitat, favorable summer water temperatures, and distance from the primary fall-run spawning areas farther downstream. Although water temperatures in this reach are believed to be most suitable for spring-run holding, spawning, and egg incubation, the lack of suitable spawning substrate currently limits spawning success. Spring-run Chinook salmon are known to hold in this reach and attempt to spawn despite the lack of suitable spawning habitat (NMFS 2007).

#### 6.2.3.2 Lack of Temporal or Spatial Segregation of Spawning Spring-Run and Fall-Run

Englebright Dam is a complete migration barrier to anadromous fish, precluding migration of Chinook to historical holding and spawning upstream of the dam. Consequently, both fall-run and spring-run Chinook salmon are restricted to areas below the dam. Because the two runs spawn at similar times and potentially interbreed, genetic swamping of the relatively smaller numbers of spring-run Chinook salmon by more abundant fall-run fish could occur, to the detriment of the spring-run. Competition for spawning sites or destruction of spring-run redds by later-spawning fall-run fish may also occur in areas of limited spawning habitat.

### 6.2.3.3 Straying of Hatchery Fish

Straying of hatchery fish to the lower Yuba River represents another potential constraint to establishing a productive, locally adapted stock of spring-run Chinook salmon in the lower Yuba River. Given the proximity of the Feather River Hatchery and current planting practices, it is likely that hatchery strays make up a significant fraction of the spring-run fish that occur in the Yuba River. The potential risk posed by these fish to establishing a Yuba River spring-run stock is heightened by the uncertain genetics of Feather River Hatchery fish (Hedgecock et al. 2001).

### 6.2.3.4 Fish Passage Impediments

Daguerre Point Dam is recognized as an impediment to upstream migration of adult salmon and steelhead under certain flow conditions. Adult passage through the existing fish ladders is severely impaired during high flows (≥ 2,000 cfs) that commonly occur during the spring-run Chinook salmon and steelhead upstream migration periods (NMFS 2007, ENTRIX and Monroe 2002). Factors contributing to reduced passage success include inadequate attraction flows, proximity and orientation of the ladder entrances to the spillway, periodic obstruction of the ladders by sediment and woody debris, and operating criteria that require closure of the ladders at high flows (NMFS 2007). Under these conditions, adult salmon and steelhead are subject to delay and injury as they attempt to ascend the dam face, potentially leading to reduced disease resistance, increased pre-spawning mortality, and reduced egg viability. Adult spring-run Chinook salmon are particularly sensitive to such delays because of their need to conserve energy for summer holding and maturation, and they need to reach suitable holding areas before downstream water temperatures reach harmful levels. Daguerre Point Dam may also adversely affect juvenile salmon and steelhead outmigration success. During downstream migration, juvenile salmon and steelhead may be disoriented or injured as they plunge over the spillway, increasing their exposure and vulnerability to predators in the large pool at the base of the dam.

### 6.2.3.5 Lack of Habitat Complexity

Historical gold mining activities in the Yuba River watershed dramatically reduced the diversity and complexity of riverine, floodplain, and riparian habitats in the lower Yuba River. Within the Goldfields reach (RM 8–15), confinement of the river by massive deposits of cobble and gravel derived from hydraulic and dredge mining activities resulted in a relatively simple river corridor dominated by a single main channel and large cobble-dominated bars, with little riparian and floodplain habitat. Englebright Dam has contributed to reductions in habitat complexity and diversity by preventing the transport of sediment, woody material, and nutrients from upstream sources to the lower river.

Low habitat complexity and diversity has been identified as a limiting factor for salmon and steelhead production in the lower Yuba River, primarily through its effect on juvenile rearing success (Lower Yuba River Fisheries Technical Group 2005). Loss of off-channel habitats such as floodplains, riparian, and wetland habitats has substantially reduced the productive capacity of the Central Valley for many native fish and wildlife species, and there is growing evidence that such habitats were once of major importance for the growth and survival of juvenile salmon (Moyle 2002). Recent observations on the lower Yuba River indicate that remnant side channels and associated riparian vegetation play a similar role by providing flood refugia, protection from predators, and abundant food for young salmonids and other native fishes. These habitats also promote extended rearing and expression of the stream-type rearing characteristic of spring-run Chinook salmon.

# 6.3 Contribution to the HET

The potential contribution of Lower Yuba River Actions to the HET was evaluated using the HET contribution procedure. Refer to Appendix E for a summary of the HET contribution that was determined for the Lower Yuba River Actions.

The procedure focused on the contribution of actions in the Englebright Dam reach of the river. This includes actions to rehabilitate spawning habitat in the reach and to augment gravel in the lower portion of Deer Creek, a tributary to the Yuba River, at the downstream end of the reach. The Lower Yuba River Actions also include an action to restore side-channel habitat for juveniles in the Yuba Goldfields area about 6 miles below the Narrows.

In the evaluation, restoration of floodplain and side-channel habitat below the Narrows was assessed as an increase in spring-run Chinook salmon restoration potential and an increase in the benefits provided by the actions in the Englebright Dam reach and lower Deer Creek. The possible value of a segregation weir was assessed as a projected conversion of benefits from total Chinook (spring-run and fall run) to benefits only for spring-run Chinook.

Applying the HET contribution procedure to these actions indicate that the recommended actions in the lower Yuba River would achieve the HET (Table 6-1). The bulk of that benefit would derive from spawning habitat rehabilitation in the Englebright Dam reach. The Lower Yuba River Actions collectively would contribute approximately 3,450 spring-run Chinook salmon to the HET.

**Table 6-1.** Contribution of Actions in the Lower Yuba River to the Habitat Expansion Threshold

| Action | Spring-Run Chinook Salmon[a] |
|---|---|
| Spawning habitat rehabilitation | 2,523 |
| Deer Creek gravel augmentation | 70 |
| Segregation weir | 735 |
| Juvenile rearing habitat restoration | 130 |
| **Total contribution to the HET** | **3,459** |

[a] Values reflect the number of adult fish supported by habitat expansion. The estimated contribution of an action to the HET represents an index of the increase in quality and quantity of habitat for spring-run Chinook salmon. Actual results of the actions could differ due to a variety of factors.

# 6.4 Spawning Habitat Rehabilitation

## 6.4.1 Description

This recommended action involves the following components to restore and expand spring-run Chinook salmon and steelhead spawning habitat in the Englebright Dam reach of the Yuba River (RM 23–24) and in the lower portion of Deer Creek, a tributary to the Yuba River:

- removal of shot rock from Sinoro Bar at the lower end of the Englebright Dam reach,
- placement of gravel at Sinoro Bar as replacement for the removed shot rock, and
- placement of gravel in lower Deer Creek.

These components are consistent with recommendations of Dr. Greg Pasternack, based on an analysis of historical channel conditions in this reach (Pasternack 2008, 2009). Historically, gravel bars suitable for spawning were present in what is known as the Englebright Dam reach; however, spawning habitat is now severely limited due to a lack of gravel. Rehabilitation of spawning habitat in the Englebright Dam reach would benefit spring-run Chinook salmon in particular, as spring-run are known to hold and attempt to spawn in this reach despite the lack of suitable spawning habitat.

### 6.4.1.1 Shot Rock Removal

Shot rock is irregularly shaped (angular) rock blasted from surrounding canyon slopes. In the Englebright Dam reach, it originated from rock excavation during construction of Englebright Dam and hillside scouring during major floods. The largest of the three shot rock deposits in this reach is at Sinoro Bar, which is located on the north bank of the Yuba River above Deer Creek (Figure 6-2). This deposit is a mixture of angular gravel, cobble, and boulders.

Pasternack (2009) applied a digital elevation model to determine the spatial pattern of fill depth and total volume of sediment stored in Sinoro Bar. The model yielded an estimated total volume of sediment of 128,940 cubic meters ($m^3$) and a fill depth range of 0–12.1 meters (m). This estimate was assumed to be the maximum volume of shot rock deposited at Sinoro Bar; the actual volume could be substantially less.

The shot rock would be removed in a stepwise manner. A pilot program would be initiated to remove the shot rock on the surface of the bar in order to determine the underlying materials. Digging and removal of shot rock would continue until the full extent of shot rock had been removed. The bulk of the shot rock would be removed from the site. However, some of the shot rock would be used to fill holes in the stream channel created by mining operations, and some would be incorporated into the final design of the spawning beds to be created during the gravel placement phase.

### 6.4.1.2 Gravel Placement

To create spawning habitat on Sinoro Bar, clean gravel of suitable spawning size would be placed in areas where shot rock had been removed, and the bar would be modified as needed. Pasternack (2009) estimates that approximately 100,000 $m^3$ of gravel would be needed for the initial gravel placement (roughly two-thirds the volume of Sinoro Bar itself). Modification of the resulting bar would include placement of shot rock and contouring of the gravel to maximize the stability of the bar and the sustainability of the spawning habitat.

Additionally, gravel placement and resulting spawning habitat rehabilitation would be extended from the lower end of Sinoro Bar across the Yuba River to the mouth of Deer Creek. Newly created spawning habitat at the mouth of Deer Creek would be supplemented by the Deer Creek gravel augmentation program described below.

Long-term sustainability of the spawning habitat would be accomplished through a long-term gravel augmentation program that the Corps is required to perform. Under two biological opinions issued by NMFS, the Corps is required to develop and implement a long-term gravel augmentation program in the Yuba River below Englebright Dam (NMFS 2002, 2007). In November 2007, a pilot gravel injection project was initiated by the Corps, with 450 metric tons of spawning-

sized gravel placed at the base of Englebright Dam. Monitoring and evaluation of this gravel injection project is currently underway.

#### 6.4.1.3 Gravel Augmentation in Deer Creek

Placement of gravel in the lower portion of Deer Creek would help rehabilitate spawning habitat in both Deer Creek and the Yuba River at the mouth of Deer Creek. However, a comprehensive gravel augmentation program cannot be undertaken in Deer Creek until additional investigations of flow and channel conditions are conducted. Thus, this component also would be implemented in a stepwise manner.

A pilot program would be initiated to inject approximately 500 tons of suitable spawning gravel in Deer Creek at the Mooney Flat Road crossing. The success of the pilot program would be determined based on the creation of suitable spawning habitat in lower Deer Creek and contribution to spawning habitat in the Yuba River at the mouth of Deer Creek. Assuming that the results of the evaluation were positive, gravel would be injected at the 500-ton level annually for 3 years following the initial injection. According to the questionnaire submitted for this action by Friends of Deer Creek, the Lake Wildwood Association would provide maintenance over the long term following the 3-year period.

### 6.4.2 Objectives and Benefits

The spawning habitat rehabilitation action of the Lower Yuba River Actions would address the substrate changes that have developed from construction and operation of Englebright Dam. Historically, spring-run Chinook salmon and steelhead migrated far beyond the existing dam site and spawned in higher elevation reaches of the watershed. With Englebright Dam acting as a complete barrier to upstream migration, salmon and steelhead are now limited to spawning in the lower river below the dam. The existing spawning habitat has been altered by scouring of gravel beds downstream of the dam, blockage of downstream movement of source gravel at the dam, and deposition of shot rock at three primary locations within the Englebright Dam reach. This has resulted in a virtual lack of suitable spawning habitat in this reach.

The lack of suitable spawning gravel in the Englebright Dam reach is a critical limiting factor for spring-run Chinook salmon in the lower Yuba River. The primary objective of the spawning habitat rehabilitation action is to address this limiting factor by creating suitable spawning areas in the Yuba River at Sinoro Bar and at the Deer Creek confluence.

Note: Sinoro Bar, Area 3, is the proposed site for spawning habitat rehabilitation

Source: Adapted from Pasternack 2008

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**Figure 6-2**
**Yuba River Shot Rock Deposits**

## 6.4.3 Contribution to the HET

Assuming a 25% spawning overlap for spring-run and fall-run Chinook salmon in the lower Yuba River, the spawning habitat rehabilitation action was estimated to provide habitat for approximately 2,600 spring-run Chinook salmon, without inclusion of a segregation weir or juvenile habitat restoration (these components of the Lower Yuba River Actions are discussed in Sections 5.4 and 5.5, respectively).

Refer to Appendix E for a summary of the HET contribution that was determined for the spawning habitat rehabilitation action associated with the Lower Yuba River Actions.

## 6.4.4 Estimated Cost

### 6.4.4.1 Capital Cost

The pre-feasibility-level capital cost estimate for the spawning habitat rehabilitation component is approximately $10.5 million.

### 6.4.4.2 Operations and Maintenance

Annual O&M costs would not be required by the Licensees for this action. After the shot rock removal and gravel placement are implemented on the Yuba River, the Corps would be responsible for a long-term gravel injection program to maintain the spawning habitat created under this action. Costs for gravel augmentation on Deer Creek, (1 year pilot and 3 years of maintenance) are included in the estimated capital costs. Any recommended gravel augmentation on Deer Creek beyond the 4 years identified under this action was assumed to be carried out by Lake Wildwood Association or other parties.

### 6.4.4.3 Funding Partners

Currently, no funding partners have been identified for the capital portion of the spawning habitat rehabilitation component. Long-term maintenance would be provided by the Corps for the Englebright Reach and Lake Wildwood Association for Deer Creek.

## 6.4.5 Implementation Schedule

Design and permitting work for spawning habitat rehabilitation could be initiated as soon as approval is received on the HEP and the Licensees receive FERC licenses for their respective hydroelectric projects. The design and permitting phase of this action is assumed to require from 1 to 2 years.

Shot rock removal and gravel placement in the Yuba River would be completed over a single summer/fall season. It is assumed that heavy equipment would need to be driven down a road on the south side of the river and then across the river to Sinoro Bar on the north bank. The actual timing of this work would depend on the magnitude of flow releases below Englebright Dam and requirements established under a DFG Streambed Alteration Agreement.

The initial gravel injection in Deer Creek (pilot program) would be conducted during the same summer/fall season as the work at Sinoro Bar. Any additional gravel injections would be completed in subsequent years during the summer/fall season.

## 6.4.6 Implementation Responsibilities of Licensees

As soon as NMFS approves the final HEP, the Licensees would prepare a Preliminary Design Report for the spawning habitat rehabilitation action. When the Licensees accept each of the new FERC licenses for the Oroville, Poe, and Upper North Fork Feather River Projects, the Licensees would begin the final design and permitting phase. Rehabilitation of the spawning habitat would include removal of shot rock from Sinoro Bar at the lower end of the Englebright Dam Reach; gravel augmentation as replacement for the removed shot rock; initial placement of gravel in lower Deer Creek, tributary to the lower Yuba River; and gravel augmentation in lower Deer Creek for an additional 3 years. Further project details would be developed through field testing, agency discussions, and additional geomorphologic modeling by Dr. Greg Pasternak as needed.

This action would be coordinated as much possible for logistical efficiencies with the juvenile rearing habitat action. Each Licensee would be responsible for one-half of the total costs of this action. The Licensees would consult with landowners and other stakeholders throughout the planning and implementation phases and would jointly hire contractors to complete the work.

The Licensees would not provide long-term gravel augmentation below Englebright Dam once the initial spawning habitat is restored, as the Englebright Dam and Daguerre Point Dam biological opinions specify long-term gravel augmentation as the responsibility of the Corps (NMFS 2002, 2007).

## 6.4.7 Rationale for Selection

Appendix C4 presents the scoring results when the HEA Evaluation Criteria were applied to the Lower Yuba River Actions, and Appendix C5 presents the scoring results when the HEA Selection Criteria were applied to the combined actions.

The spawning habitat rehabilitation action would meet the HET by providing habitat for approximately 2,550 spring-run Chinook salmon. Currently, both spring-run and fall-run Chinook salmon spawn in the lower Yuba River. Early-arriving adults (i.e., phenotypic spring-run) tend to spawn farther upstream than later arrivals (i.e., phenotypic fall-run). Due to low numbers of spawning fish and the occurrence of some natural segregation between these runs, only a small amount of spawning overlap is considered to be occurring. Even assuming as much as a 25% spawning overlap between spring-run and fall-run Chinook salmon, the estimated contribution of the spawning habitat rehabilitation component for spring-run salmon by itself (i.e., without either a segregation weir or juvenile habitat restoration) would achieve the HET.

The spawning habitat rehabilitation action would support establishing a separate, self-sustaining (i.e., independent) population of spring-run Chinook salmon. Currently, the phenotypic spring-run fish in the lower Yuba River are not recognized as an independent population due to low numbers of spawning fish and questions of genetic integrity. Providing a substantial amount of suitable spawning habitat in the upper portion of the lower river (i.e., the Englebright Dam reach), where little spawning habitat currently exists and where spring-run are known to attempt to spawn, would contribute to establishing an independent spring-run Chinook salmon population by increasing abundance and productivity. Additionally, creation of spawning habitat in the Englebright Dam reach would allow spring-run salmon to spatially separate from fall-run salmon, which tend to spawn farther downstream. The addition of a segregation weir would further contribute to establishing an independent population of spring-run Chinook salmon.

The spawning habitat rehabilitation action is cost effective and feasible, can be accomplished in a reasonable period of time, and has broad local and political support. The combination of its estimated total cost of $10.5 million and a contribution of approximately 2,550 adult spring-run Chinook salmon makes it one of the more cost-effective actions considered. Creation of spawning beds through restoration of the stream channel and focused injection of suitable spawning gravel is a proven technology and has been shown to be highly successful. Because much work related to this action has already been accomplished (i.e., identification of treatment location and magnitude) (Pasternack 2008, 2009), it is ready for the design and permitting phase. Once this phase is accomplished, the action could be implemented in less than 1 year, and benefits to spring-run Chinook salmon could be realized during the following spawning season. Finally, members of the RMT support the Lower Yuba River Actions, as documented in Appendix G.

## 6.4.8 Other Issues

During development of the spawning habitat rehabilitation action, three potential issues were identified: eligibility under Section 3.2 of the HEA, local support, and permitting requirements for instream work. Each of these issues is discussed below.

### 6.4.8.1 Eligibility

The issue of eligibility relates to the Corps' responsibility for performing a gravel augmentation program in the lower Yuba River, as required by two biological opinions issued by NMFS for the Corps' operation of Englebright Dam and Daguerre Point Dam (NMFS 2002, 2007). Specifically, the most recent of these biological opinions contains, as one of its Reasonable and Prudent Measures, the following:

1. *The Corps shall develop and implement a long-term gravel augmentation program to restore quality spawning habitat below Englebright Dam.*

   A) *The Corps shall utilize information obtained from the pilot gravel injection project to develop and commence implementation of a long-term gravel augmentation program within three years of the issuance of this biological opinion.*

The Corps initiated a pilot gravel injection project in November 2007, with placement of 450 metric tons of spawning-sized gravel at the base of Englebright Dam. Monitoring and evaluation of this gravel injection project are currently underway.

Under the HEA, the Licensees are proposing to implement a spawning habitat rehabilitation program. This program is much broader in scope than a gravel augmentation program, which is the responsibility of the Corps. Wheaton, Pasternack, and Merz (2004) define and contrast spawning habitat rehabilitation and gravel augmentation. They define *spawning habitat rehabilitation* as being segregated into three categories: gravel augmentation, hydraulic structure placement, and spawning bed enhancement. The spawning habitat rehabilitation action proposed by the Licensees includes activities within all three of these categories to create the basis for sustainable spawning habitat in the Englebright Dam reach. In contrast, the Corps' responsibility is simply for gravel augmentation (i.e., long-term gravel injection similar to the pilot project initiated by the Corps in 2007). Ultimately, the Corps' gravel augmentation program would provide long-term sustainability for the spawning habitat created by the Licensees under the HEA.

#### 6.4.8.2 Local Support

The Licensees would need to engage local landowners to obtain permission for accessing the stream channel in order to conduct the spawning habitat rehabilitation work. This is particularly pertinent for accessing Sinoro Bar on the Yuba River. It is likely that access would be required for heavy equipment by way of a road located on private land holdings on the south side of the river. The Licensees plan to contact these landowners and other stakeholders through the HEA outreach program.

#### 6.4.8.3 Permitting Requirements for Instream Work

Several permits would be required to conduct the spawning habitat rehabilitation work. An issue of particular note is the timing of instream work at Sinoro Bar. Assuming that heavy equipment would be moved down to the south side of the river, it would need to be moved across the river to reach Sinoro Bar on the north bank. Due to high streamflow conditions below Englebright Dam during most of the year, as required by the Yuba River Accord, the window of opportunity for moving the equipment across the river likely would be limited to the late summer/fall period. This period would at least partially overlap with the spawning period for both spring-run and fall-run Chinook salmon. Thus, the potential sensitivity to conducting the instream work would need to be addressed.

## 6.5 Segregation Weir

### 6.5.1 Description

The HEA directs that actions are to benefit spring-run Chinook salmon and steelhead, and should encourage the separation of fall-run and spring-run Chinook. During years with high escapement, superimposition and competition for appropriate spawning habitat with fall-run Chinook salmon can be a limiting factor for spring-run Chinook salmon. For this reason, the Lower Yuba River Actions include an adaptive management action to construct and operate a segregation weir at Timbuctoo Bend that would allow for mechanical separation of the two runs, if deemed necessary in the future. Although this action does not independently expand available habitat, inclusion of the action could considerably enhance the value of the other Lower Yuba River Actions relative to the HEA criteria.

The seasonal segregation weir would be used to provide exclusive access for spring-run Chinook salmon to the uppermost holding and spawning habitat on the lower Yuba River between Englebright Dam (RM 24) and the Highway 20 Bridge (RM 18). This reach contains the highest quality spring-run salmon holding and spawning habitat in the lower Yuba River based on the frequency of large, deep pools; proximity to spawning habitat; and favorable summer water

temperatures. The weir would be operated (or removed) to permit passage of Chinook salmon during the primary spring-run Chinook salmon migration period and operated (or installed) to prevent passage of Chinook salmon during the primary fall-run Chinook migration period. Passage of steelhead migrating during the latter period would need to be addressed in the design and construction and/or operation of the weir.

The location, seasonal operation, and design of the weir would need to be determined based on migration timing, channel and flow characteristics, and habitat needs (i.e., the amount of habitat needed to establish a viable spring-run Chinook salmon population). Preliminary acoustic tagging studies have indicated that some portion of spring-run Chinook salmon may hold downstream of Daguerre Point Dam until early fall (RMT pers. comm.). Based on this preliminary information, it is unclear what proportion of spring-run salmon hold below the dam; consequently, this issue would require further investigation to determine appropriate timing of operation.

Another major consideration would be the ability of the weir to operate effectively over the range of flows anticipated during the primary fall-run Chinook migration period (July through December). This suggests possible use of a resistance board weir. These weirs rely on a cable anchored to the substrate at the upstream end of the weir site. Panels with some form of floatation on one end and a shackle on the other are then secured to this cable. This arrangement provides an impassable barrier to anadromous salmonids, while allowing boats and debris to depress the weir and pass over the top (Stewart 2003). In periods of extremely high flow, this type of weir is designed to lie along the bottom due to the increased force of the water. Resistance board weirs have been used extensively in Alaska and on the Stanislaus River in California (Anderson et al. 2007) to provide segregation. Board weirs can also accommodate video monitoring to estimate abundance, another element that could be incorporated into this action, if needed.

## 6.5.2 Objectives and Benefits

The objective of the segregation weir option is to provide a mechanical means of spatially segregating spring-run Chinook salmon from fall-run Chinook salmon. Both runs have been confined to the lower reaches of the Yuba River since construction of Englebright Dam in 1941 (DFG 1991). Spring-run Chinook salmon are unable to migrate beyond this barrier into the higher elevation reaches they historically occupied and are therefore unable to naturally segregate themselves from fall-run Chinook salmon. This spawning overlap threatens the spring-run population in a variety of ways, including destruction of redds due to superimposition, competition for spawning grounds limiting the usable habitat for spring-run salmon, and introgression causing the loss of a genetically distinct spring-run Chinook salmon.

Installation of a segregation weir addresses all three of these issues. By using the weir to exclude fall-run Chinook salmon from the habitat being utilized by

spring-run Chinook salmon, superimposition of fall-run redds upon the earlier constructed spring-run redds would be minimized. Similarly, competition for spawning habitat would be minimized by removing fall-run Chinook salmon from specific reaches designated as spring-run Chinook salmon habitat. Genetic introgression is one of the largest issues associated with the limitations imposed upon spring-run Chinook salmon by large dams. Spawning overlap contributes hybridization between fall-run and spring-run Chinook salmon, thereby compromising genetic distinctions between the two runs. Additionally, strays from the Feather River Hatchery potentially compromise the Yuba River spring-run Chinook salmon genetics (Reedy pers. comm.). By installing a segregation weir and preserving the spring-run Chinook salmon phenotype, it is likely that the spring-run genotype would also be preserved. Waples et al. (2004) suggest a coarse estimate that, in most basins (including the Sacramento River basin), the spring-run genotype may have evolved in a period as short as 80–100 years. Given the current phenotypic spring-run Chinook salmon stock present in the lower Yuba River, it is likely that restoration and conservation of spring-run Chinook salmon genetics could be realized in a considerably shorter period following spatial segregation.

### 6.5.3 Contribution to the HET

Currently, the fall-run and spring-run Chinook salmon populations in the lower Yuba River are at sufficiently low numbers that spawning overlap is not considered a limiting factor. In years when escapement is high, however, spawning overlap could threaten the spring-run population. Additionally, the timing of operation of the weir is dependent on further investigations into the holding behaviors of spring-run Chinook salmon in the lower Yuba River (e.g., acoustic tagging). Applying the HET contribution procedure, the segregation weir associated with the Lower Yuba River Actions has the potential to contribute habitat for approximately 750 spring-run Chinook salmon, specifically (rather than habitat for both fall-run and spring-run Chinook salmon). Because this action is being considered as a future adaptive management tool, it is not possible to predict the increase in contribution to the HET at the time of its implementation. The increase would be calculated if it is determined that the segregation weir should be incorporated into the Lower Yuba River Actions.

Refer to Appendix E for a summary of the HET contribution that was determined for the segregation weir associated with the Lower Yuba River Actions.

## 6.5.4 Estimated Cost

### 6.5.4.1 Capital Cost

The pre-feasibility capital cost estimate for installing a resistance board weir to segregate spring-run Chinook salmon from fall-run Chinook salmon, including permitting, design, and construction, is approximately $300,000.

### 6.5.4.2 Operations and Maintenance

Pre-feasibility cost estimates for O&M include annual installation and removal of the weir, and repairs as necessary. Annual O&M costs are estimated at approximately $52,000. Over the course of a 50-year license, O&M costs are conservatively estimated to be $2.6 million. This amount is likely an overestimate because installation of the segregation weir would be dependent on necessity and spring-run holding behavior.

### 6.5.4.3 Funding Partners

Currently, no funding partners have been identified for the segregation weir element of the Lower Yuba River Actions.

## 6.5.5 Implementation Schedule

Implementation of the segregation weir would occur following the spawning habitat rehabilitation upstream. In addition to consideration of the spawning habitat rehabilitation, installation would depend on necessity. With local stakeholder and agency support, implementation would likely be possible in less than 1 year following the decision to proceed. However, this action would be adaptively managed and would be implemented only if spawning overlap was determined to be a major limiting factor within the upper reaches of the lower Yuba River and if the weir was supported by the resource agencies.

## 6.5.6 Implementation Responsibilities of Licensees

As soon as NMFS approves the final HEP, the Licensees would prepare a Preliminary Design Report for implementation of the segregation weir. When the Licensees accept each of the new FERC licenses for the Oroville, Poe, and Upper North Fork Feather River Projects, the Licensees may begin the final design and permitting phase for implementation of the segregation weir,

assuming that consensus exists that the weir is needed to provide separation of spring-run Chinook salmon from fall-run Chinook salmon.

Each Licensee would be responsible for one-half of the capital costs, including permitting, design, and construction of the weir, and one-half of the O&M costs, including annual installation and removal and necessary repairs. It is possible that the Licensees could provide funding for DFG or another party for the long-term operation and maintenance of the structure. The Licensees would consult with other stakeholders throughout the planning and implementation phases.

## 6.5.7 Rationale for Selection

Appendix C4 presents the scoring results when the HEA Evaluation Criteria were applied to the Lower Yuba River Actions, and Appendix C5 presents the scoring results when the HEA Selection Criteria were applied to the Lower Yuba River Actions.

The decision to include this element in the Lower Yuba River Actions as an adaptive measure is due to the potentially significant increase in benefits by using a segregation weir in concert with the other suite of actions in the lower Yuba River. As an independent action, the feasibility of segregation weirs has been proven and time to implement the action would likely be rapid because of the limited impacts and construction required. When spawning overlap is likely to be problematic due to high escapement, installation of the segregation weir would increase the degree to which the other elements of the Lower Yuba River Actions fulfill the HEA Evaluation and Selection Criteria, particularly favorable spatial separation to maintain genetic diversity and contribution to the HET. Regarding the contribution to the HET, if high escapement was leading to considerable spawning overlap, installing a segregation weir could increase the contribution to the HET by several hundred fish.

A corollary advantage to installation of a segregation weir includes the ability to use the segregated spring-run as stock for reintroduction to the upper Yuba River.

## 6.5.8 Other Issues

Two primary issues are associated with installation of a segregation weir on the lower Yuba River. These concerns related to potential adverse effects on spring-run Chinook salmon and adverse effects on fall-run Chinook salmon.

Preliminary results indicate that at least some phenotypic spring-run Chinook salmon hold in the pool immediately downstream of Daguerre Point Dam. The proportion of spring-run holding downstream is still unclear. A primary concern related to installing a segregation weir is unintentional exclusion of spring-run Chinook salmon from the habitat above the weir. This could result from spring-

run Chinook salmon migrating late during the typical fall-run Chinook salmon migration period.

The other concern is that the segregation weir could negatively affect fall-run Chinook or steelhead by decreasing the available spawning area. Therefore, if the weir is determined to be necessary, it is essential that installation timing and operations minimize potential negative impacts on spring-run Chinook salmon holding downstream, as well as fall-run Chinook salmon and steelhead.

# 6.6 Juvenile Rearing Habitat Restoration

## 6.6.1 Description

The juvenile rearing habitat restoration action addresses historical reductions in off-channel rearing and riparian habitat that currently limit production and life history variability of juvenile spring-run Chinook salmon and steelhead in the lower Yuba River. SYRCL recently prepared a proposal that focuses initially on planning and design for restoration of off-channel rearing habitat in the 3-mile reach below the Highway 20 Bridge. This is considered a key reach for restoration because of its proximity to the primary spring-run Chinook salmon and steelhead spawning reaches, favorable rearing temperatures, and limited extent of off-channel habitat. Long-term habitat restoration goals are aimed at the reach throughout the Yuba Goldfields. The action would complement a current AFRP-funded pilot restoration project and a 180-acre conservation easement on land in the Yuba Goldfields owned by Western Aggregates. The general targets identified by SYRCL for the initial phase of the action are restoration of 5 acres of backwater or side-channel habitat and restoration of 50 acres of functional floodplain with enhanced riparian habitat.

The proposed juvenile rearing habitat restoration action would involve construction of side-channel habitat, enhancement of an existing backwater connected to the mainstream Yuba River, and placement of in-channel structures to provide variability in flow characteristics and to create hydraulic controls for maintenance of side-channel structure and function. Construction of side channels would be achieved by reconnecting remnant side channels to the main river channel. A small amount of gravel excavation would be conducted at the head of the remnant side channel, and large boulders would be placed at strategic locations to direct flow from the main channel into the side channel. Flow entering the side channel would be allowed to down-cut and once again form a functioning flow-through side channel. Riparian plantings are not included in the recommended action. The remnant side channels already contain varying amounts of riparian vegetation, and the distribution of the riparian vegetation is expected to expand once the side channels are recreated.

While site-specific designs would need to be completed as part of planning, initial concepts for nine restoration sites have been identified by members of the RMT and are described below. Six of the sites are located upstream of Daguerre

Point Dam, and three of the sites are located and downstream of the dam. Figure 6-3 shows the nine juvenile rearing habitat restoration sites along the lower Yuba River. Figures 6-4 through 6-11 identify the individual locations of the potential sites for habitat enhancement.

### 6.6.1.1 Upstream of Daguerre Point Dam

Proposed restoration actions for the six sites located upstream of Daguerre Point Dam are described as follows:

- **Site 1 – Upper Guilt Edge.** Enhance the structural complexity of the left bank of the main river channel. Line the left bank of the main channel with boulder/wood structures and enhance an ephemeral backwater with boulder/wood structures to maintain aquatic habitat. See Figure 6-4.
- **Site 2 – First Island.** Create a side channel in an existing swale within a stand of relatively dense riparian vegetation. Enhance the structural complexity of the left bank of the main river channel by placement of large wood material. See Figure 6-5.
- **Site 3 –North Silica Bar** (bar opposite the Silica Bar side channel). Create a side channel in an existing swale within a stand of relatively dense riparian vegetation that presently includes willows and cottonwoods. See Figure 6-6.
- **Site 4 – Silica Bar.** Create a side channel in an existing swale within a stand of diverse, mature, native riparian vegetation. See Figure 6-6.
- **Site 5 – Hammon Bar.** Create a side channel within a stand of riparian vegetation that extends from the bar on the southern bank of the main channel into the current backwater area. Boulder structures for hydraulic maintenance may be placed at the inflow section. Wood/boulder structures may be placed at the outflow section. See Figure 6-7.
- **Site 6 – South Bar above Daguerre Point Dam.** Create a side channel within a stand of riparian vegetation and along the toe of the training wall, extending from the upper portion of the site to the existing downstream backwater area. Boulders for hydraulic maintenance may be placed at the inflow. See Figure 6-8.

### 6.6.1.2 Downstream of Daguerre Point Dam

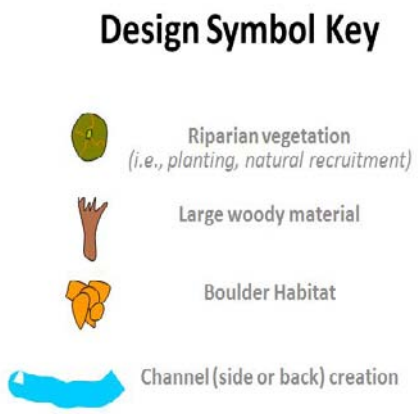
Proposed restoration actions for the three sites located downstream of Daguerre Point Dam are described as follows:

- **Site 7 – Waterway 13.** Create a side channel within a stand of riparian vegetation that extends from the main channel into the current backwater area. Boulder structures for hydraulic maintenance may be placed at the inflow section. This site would be expected to receive flow augmentation from the Yuba Goldfields return flow. See Figure 6-9.

- **Site 8 – Narrow Bar.** Create a side channel north of the main channel and following a historical channel path. Existing riparian vegetation would border the created side channel. Boulders for hydraulic maintenance may be placed at the inflow. See Figure 6-10.
- **Site 9 – Goldfields Terminus.** Create a side channel within a stand of riparian vegetation that extends into a current backwater habitat located at the downstream corner of the Yuba Goldfields. Boulder structures for hydraulic maintenance may be placed at the inflow section. See Figure 6-11.

Design plans would be guided by the information and processes listed above. The precise location of side channels and placement of structural elements would be informed by a variety of analyses, including hydraulic modeling. As evidenced by existing riparian vegetation or topography in Figures 6-4 through 6-11, many of these potential side channels follow previous alignments of the river or were side channels at some point. Additional geomorphic analysis would be necessary to fully understand the processes that originally formed these channels and subsequently moved the river to a different location. However, these features were selected based on the assumptions that: (1) side channels could be reestablished relatively easily using moderate terra-forming, boulder placement, and other techniques; and (2) constructed features would persist in the river over time.

The Design Symbol Key (below) is used in the following figures.



**Legend**

Juvenile Rearing Habitat Restoration Sites

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**Figure 6-3**
**Juvenile Rearing Habitat Restoration Sites in the Lower Yuba River**

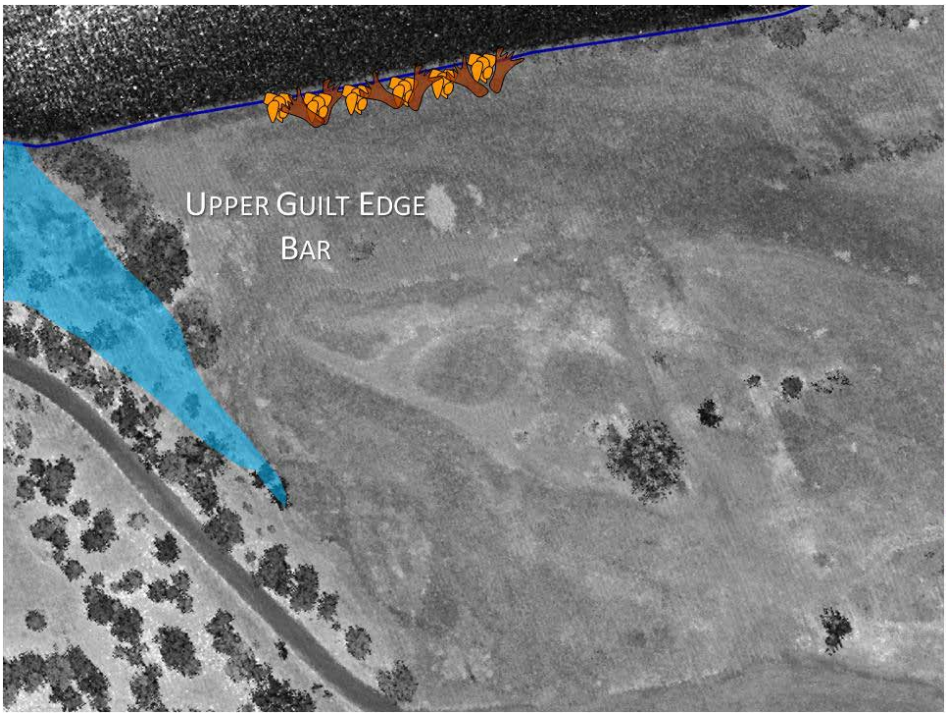


**Figure 6-4.** Upper Guilt Edge Bar Site for Juvenile Rearing Habitat Restoration

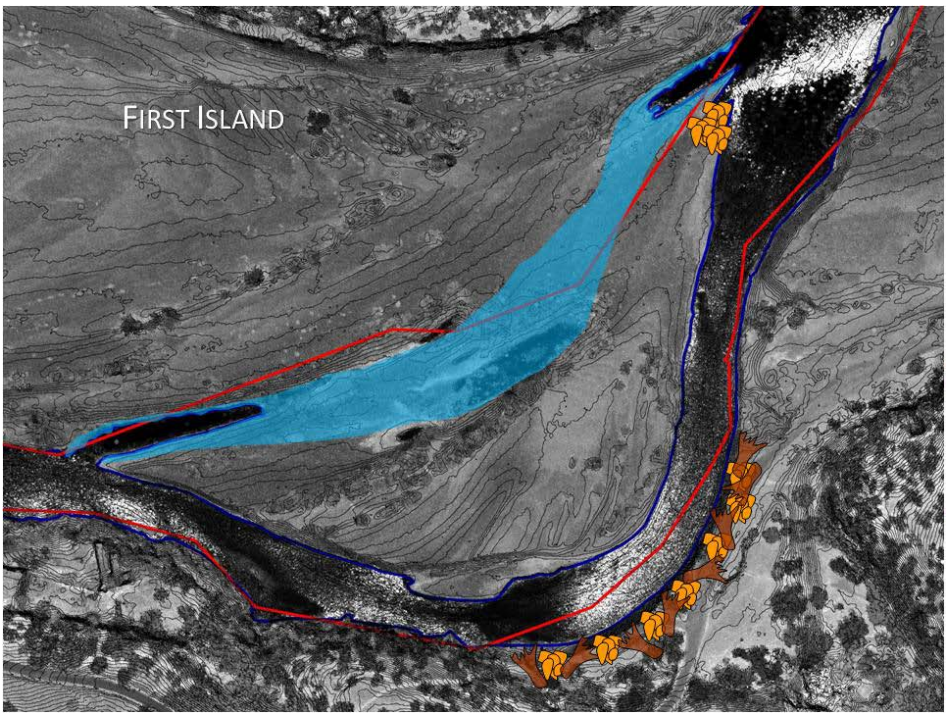


**Figure 6-5.** First Island Site for Juvenile Rearing Habitat Restoration

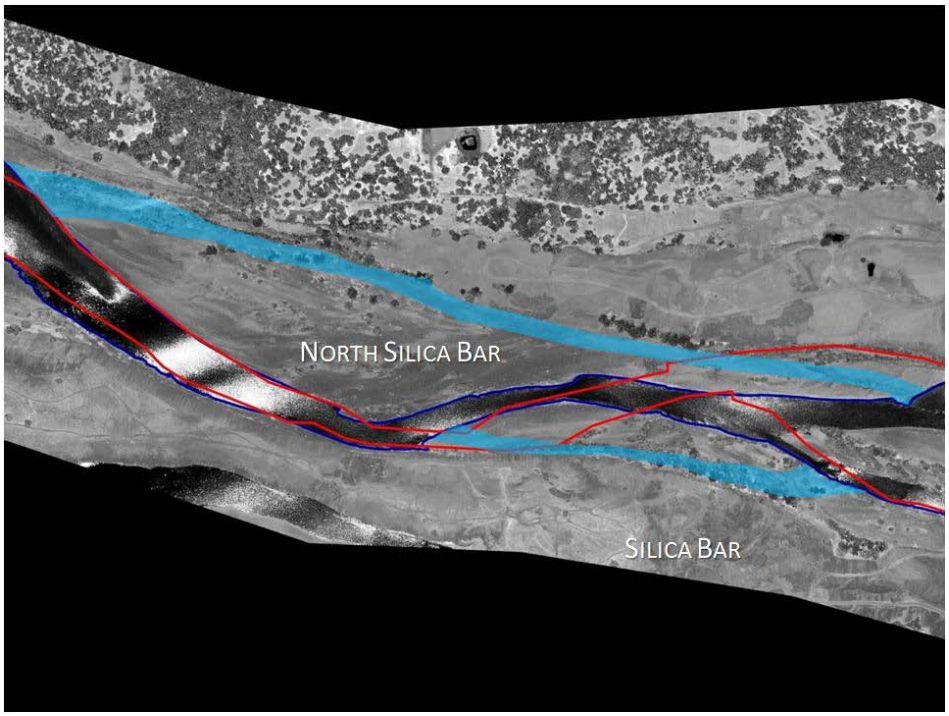


**Figure 6-6.** North Silica Bar and Silica Bar Sites for Juvenile Rearing Habitat Restoration

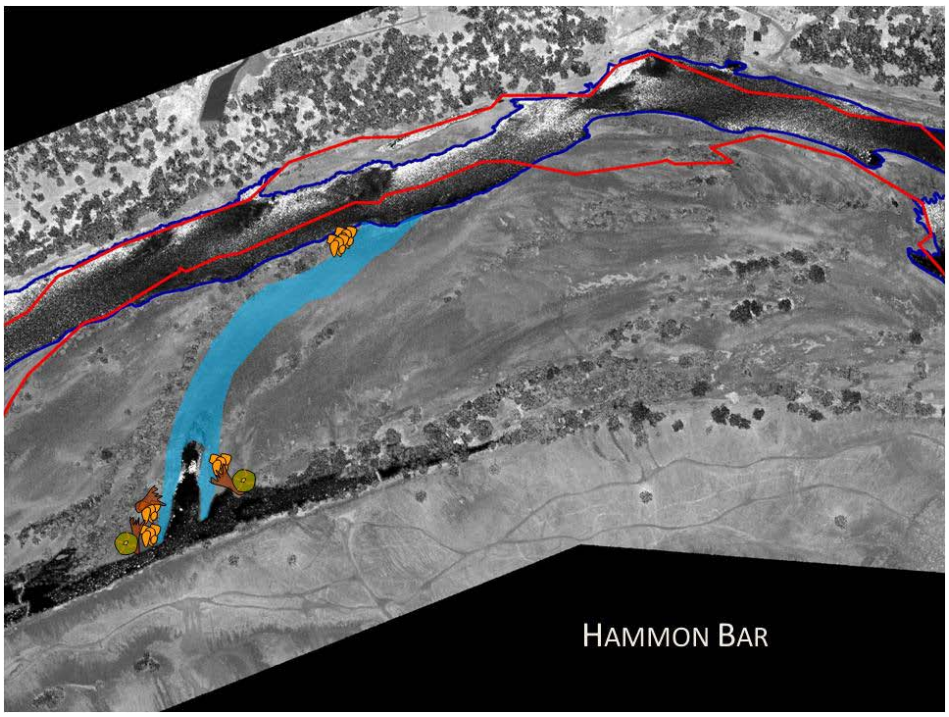


**Figure 6-7.** Hammon Bar Site for Juvenile Rearing Habitat Restoration

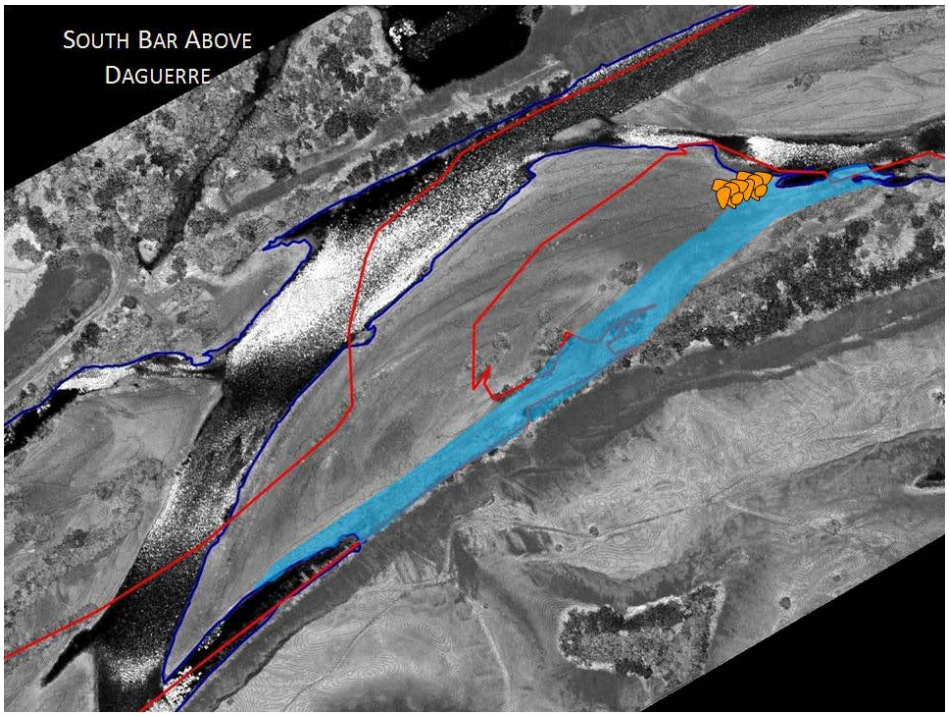


**Figure 6-8.** South Bar above Daguerre Point Dam Site for Juvenile Rearing Habitat Restoration

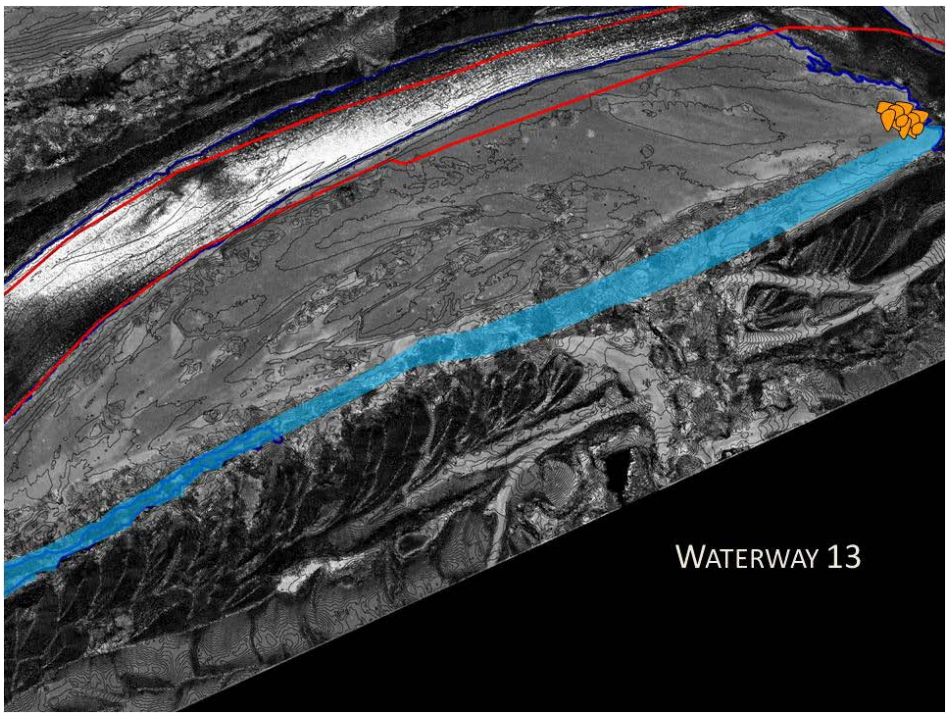


**Figure 6-9.** Waterway 13 Site for Juvenile Rearing Habitat Restoration

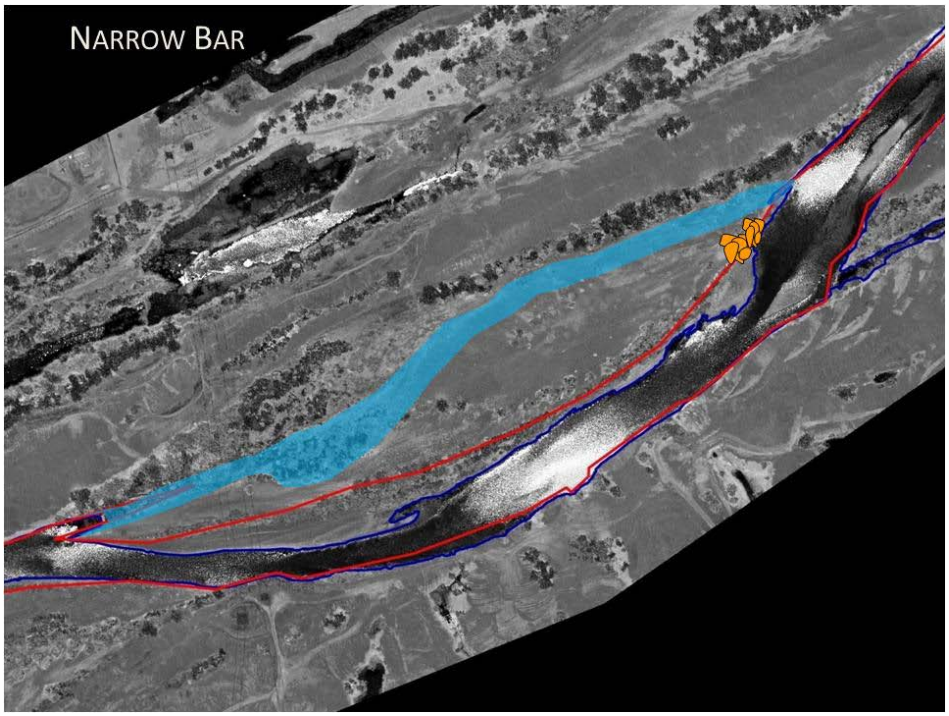


**Figure 6-10.** Narrow Bar Site for Juvenile Rearing Habitat Restoration

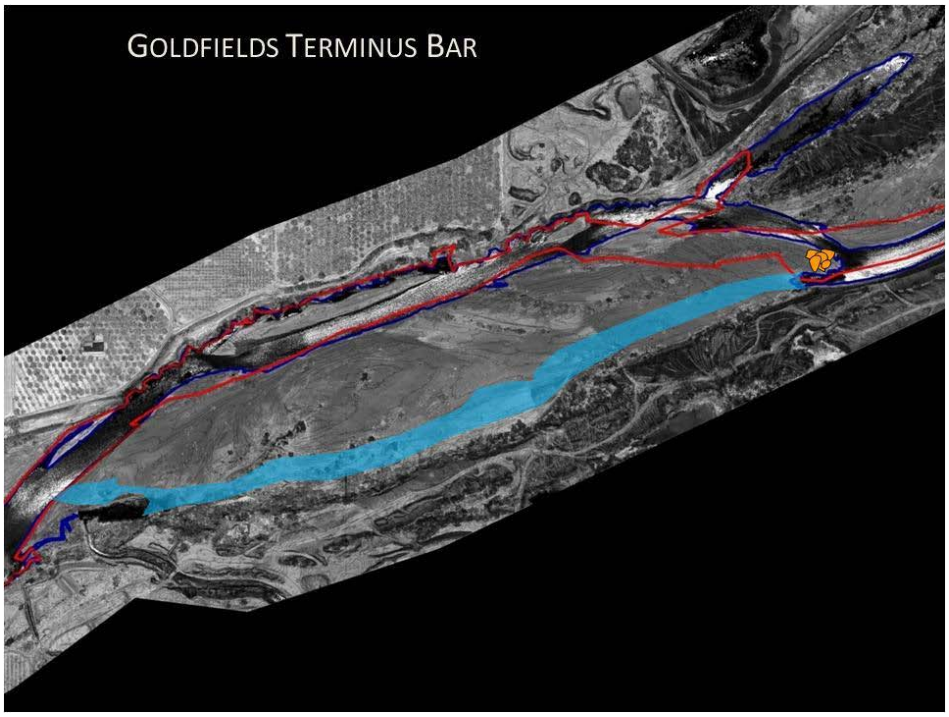


**Figure 6-11.** Goldfields Terminus Bar Site for Juvenile Rearing Habitat Restoration

## 6.6.2 Objectives and Benefits

The primary objectives of this action are to enhance off-channel rearing habitat for juvenile salmon and steelhead by constructing functioning flow-through side channels and to enhance an existing backwater. High-quality rearing habitat would provide for increased growth, protection from predators, and increased survival of juvenile salmonids and other fish species. The benefits of increased habitat complexity in the Lower Yuba River have been documented as providing refugia from predators and high water velocities and as providing efficient locations for feeding (Lower Yuba River Fisheries Technical Group 2005).

## 6.6.3 Contribution to the HET

For the purposes of estimating contribution toward the HET, restoration of floodplain and off-channel rearing habitat was considered a factor that increases the overall recovery potential of habitat upstream where spring-run Chinook salmon and steelhead spawn. Using the approach outlined in the HET contribution procedure, this action could contribute habitat for approximately 130 spring-run Chinook salmon to the Lower Yuba River Actions.

Refer to Appendix E for a summary of the HET contribution that was determined for the juvenile rearing habitat restoration action associated with the Lower Yuba River Actions.

## 6.6.4 Estimated Cost

### 6.6.4.1 Capital Cost

The pre-feasibility study capital cost estimate for implementing the juvenile rearing habitat restoration action, including permitting, design, and construction, is approximately $1.4 million. Construction costs for the action would depend in large part on the amount of gravel excavation necessary to construct side channels and restore functional floodplain habitat.

### 6.6.4.2 Operations and Maintenance

The cost of maintaining the juvenile rearing habitat component of the Lower Yuba River Actions is estimated to be $30,000 per year and $1.5 million for 50 years.

#### 6.6.4.3 Funding Partners

The USFWS AFRP has funded SYRCL for a total of $160,000 for a pilot restoration project intended to inform planning, design, and permitting for a more extensive juvenile rearing habitat project (Campbell pers. comm.). In addition, AFRP has identified funding for ongoing Yuba River salmon habitat evaluation and restoration, some of which might be available for portions of project construction or maintenance. Western Aggregates has pledged to commit $50,000 toward implementation of floodplain restoration on property they own in the area and where they have agreed to establish a 180-acre conservation easement.

### 6.6.5 Implementation Schedule

Members of the RMT have suggested (Appendix G) that, because several tools are already in development and the pilot restoration project design is currently underway, (1) preliminary design and permitting analysis for the juvenile rearing habitat restoration action could be completed within 1 year; (2) permitting, landowner access and other issues could be resolved within 1 or 2 years; and (3) construction could be accomplished in one to two seasons.

### 6.6.6 Implementation Responsibilities of Licensees

As soon as NMFS approves the final HEP, the Licensees would prepare a Preliminary Design Report for the juvenile rearing habitat restoration action. When the Licensees accept each of the new FERC licenses for the Oroville, Poe, and Upper North Fork Feather River Projects, the Licensees would begin the final design and permitting phase.

The juvenile rearing habitat restoration in the Yuba Goldfields reach would consist of excavating side channels and placing hard structures as hydraulic controls for the continued functioning of the side-channel habitat. The channels would be monitored and maintained over a 50-year period to ensure that they continue to function as planned. The HEA side-channel design would be coordinated with the SYRCL plans, AFRP-related planning or funded actions, and Western Aggregates floodplain restoration.

This action would be coordinated as much possible for logistical efficiencies with the spawning habitat rehabilitation action. Each Licensee would be responsible for one-half of the total costs of this action. The Licensees would consult with landowners and other stakeholders throughout the planning and implementation phases, and would jointly hire contractors to complete the work.

### 6.6.7 Rationale for Selection

Appendix C4 presents the scoring results when the HEA Evaluation Criteria were applied to the Lower Yuba River Actions, and Appendix C5 presents the scoring results when the HEA Selection Criteria were applied to Lower Yuba River Actions.

The juvenile rearing habitat restoration action complements the spawning habitat rehabilitation action by enhancing rearing habitat for expanded populations of spring-run Chinook salmon and steelhead. The feasibility of completing the juvenile rearing habitat action within 5–10 years is high for several reasons: floodplain projects targeting habitat for juvenile salmonids have been completed and considered highly successful in other Central Valley tributaries such as the Merced River, the Mokelumne River, and Clear Creek; restoration on the Lower Yuba River has a broad base of stakeholder and agency support; and costs for similar projects have been reasonable. While the estimated individual contribution toward the HET from this action is relatively small, the juvenile rearing habitat restoration action addresses important limiting factors that have been identified for spring-run Chinook salmon and steelhead production in the lower Yuba River (Lower Yuba River Fisheries Technical Group 2005). The action, combined with the spawning habitat rehabilitation action and the potential addition of a segregation weir, would result in a high contribution to the HET. Therefore, the action would support establishing a new independent population of spring-run Chinook salmon in the Lower Yuba River and is consistent with VSP guidance for recovery planning for the species.

### 6.6.8 Other Issues

Because a restoration plan and project designs have not yet been completed for the juvenile rearing habitat restoration action, constraints and challenges to completing the action may not have been fully identified. Permits and landowner permission would need to be obtained for construction at each of the restoration sites.

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Chapter 7

# Antelope Creek Habitat Expansion Action

Antelope Creek photo credit:
by Syd Temple, Questa Engineering Corporation 2008.

## 7.1 Description of Habitat Expansion Action

### 7.1.1 Background

The quality and quantity of available habitat for spring-run Chinook salmon and steelhead spawning and holding habitat in Antelope Creek are essentially the same as historical conditions; however, streamflow—in combination with other factors—limits access in low-flow years. Adult salmonid passage in Antelope Creek is affected by channel braiding in the valley floor reach; the amount of flow diverted for agriculture; and a partial barrier in DFG's Tehama Wildlife Area, known as Paynes Crossing (or Middle Slab). Paynes Crossing is a low-water crossing on Ishi Road for vehicular traffic that blocks fish passage during low flows.

### 7.1.2 Location

The partial barrier at Paynes Crossing occurs where Ishi Road crosses Antelope Creek in the DFG Tehama Wildlife Area (Figure 7-1). Other factors affecting passage (i.e., channel braiding of the lower reach of Antelope Creek and agricultural diversions) occur downstream of the Edwards Diversion Dam to the confluence with the Sacramento River.

### 7.1.3 Purpose

The Antelope Creek Action would address a key passage issue in Antelope Creek at Paynes Crossing. Neither the channel braiding of lower Antelope Creek nor the flows diverted for agriculture are addressed by this action.

### 7.1.4 Recommended Action

The Antelope Creek Action would remove an instream low-water crossing structure at Paynes Crossing and replace it with a bridge that would span the creek and allow vehicles to cross Antelope Creek.

### 7.1.5 Sources

USFWS provided information on improving fish passage at Paynes Crossing by submitting a completed HEA questionnaire to the Steering Committee. This action also is included in the PG&E/CalTrout prioritized action list and the NMFS Co-Manager Review Draft Recovery Plan.

## 7.2 Context for Action

### 7.2.1 Description of the Watershed

Antelope Creek originates in the Lassen National Forest in Tehama County, at an elevation of approximately 6,800 feet. The creek flows southwest from the foothills of the Cascade Range and enters the Sacramento River at RM 235, approximately 9 miles southeast of the town of Red Bluff. The Antelope Creek drainage encompasses approximately 123 square miles (USFWS 1995).

The Antelope Creek watershed is relatively long and narrow, with moderate to steep slopes, and is located within the southernmost extension of the Cascade Range (Armentrout et al. 1998). Although the valley reach is mainly developed for agriculture, the upper watershed is essentially undisturbed and currently supports a small number of spring-run Chinook salmon. The amount of available spawning and holding habitat for spring-run Chinook salmon and steelhead in Antelope Creek is essentially the same as historical conditions; however, low flow limits access to the upper watershed in some years (CH2M Hill 1998).

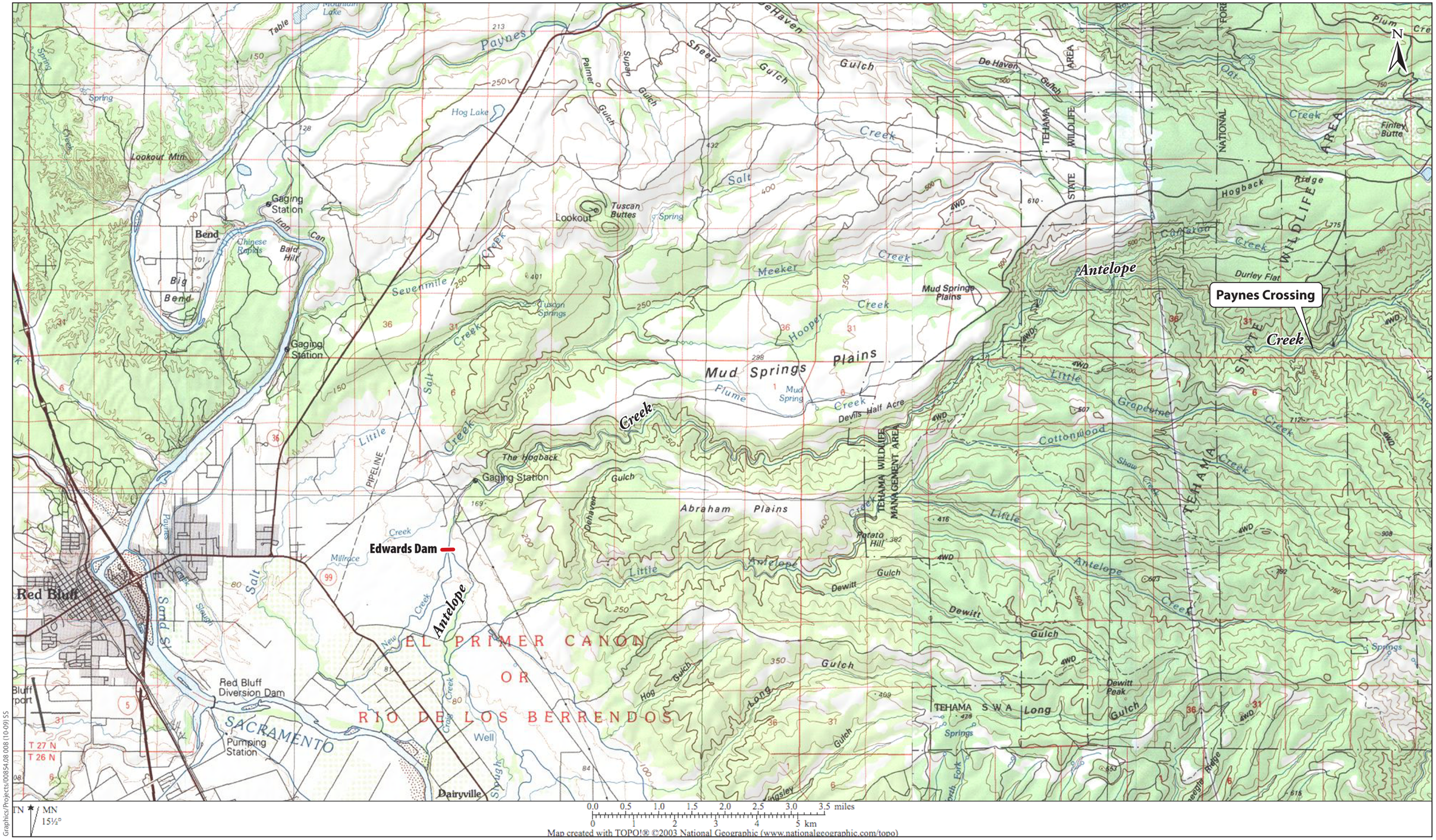


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**Figure 7-1**
**Antelope Creek Action – Paynes Crossing**

## 7.2.2 Status of Spring-Run Chinook Salmon and Steelhead Runs

### 7.2.2.1 Spring-Run Chinook Salmon

Antelope Creek historically was not known to support a large spring-run Chinook salmon population. Lindley et al. (2007) did not classify the viability of spring-run Chinook salmon in Antelope Creek, but Lindley et al. (2004) characterized the population as dependent upon other populations for its existence. The current extinction risk for this population is high, despite low hatchery influence.

The upper reaches of Antelope Creek are still relatively undeveloped and contain good salmonid habitat. Past estimates by DFG suggest that Antelope Creek can support at least 500 spring-run Chinook salmon (CH2M Hill 1998) and therefore can be characterized as having a moderate potential to support a dependent population of spring-run Chinook. Since 2000, the escapement of spring-run Chinook has ranged from 2 to 102 fish. See Appendix D for more information on the status of spring-run Chinook salmon in Antelope Creek.

### 7.2.2.2 Steelhead

Past estimates by DFG suggest that Antelope Creek can support at least 300 steelhead (CH2M Hill 1998), but the current population is unknown. See Appendix D for more information on the status of steelhead in Antelope Creek.

## 7.2.3 Limiting Factors

Flow is the primary limiting factor in Antelope Creek. Agricultural diversions in the valley reach reduce flows, impeding both upstream and downstream passage of salmonids, in addition to increasing water temperatures and reducing attraction flows. The braided channel on the valley floor can create migration barriers in low-flow years. Another migration barrier, Paynes Crossing, blocks access to summer holding and spawning habitat in low-flow years.

# 7.3 Paynes Crossing Bridge Construction

## 7.3.1 Description

The Antelope Creek Action involves replacing the existing instream roadway at Paynes Crossing with a clear span bridge. This action would allow natural stream function in passage of fish and bedload, and would improve localized narrowing of the channel. A bridge also would reduce the need for substantial annual maintenance of the low-water crossing. Construction of the bridge would involve only a minimal amount of instream work but would require approximately 3,000 yards of imported fill material to construct the roadway approaches.

## 7.3.2 Objectives and Benefits

The objective of the Antelope Creek Action is facilitating passage of spring-run Chinook salmon and steelhead to summer holding, spawning, and rearing habitat in the upper watershed, over a broader range of flows. This action would improve the channel form in the upper portion of Antelope Creek, increasing upstream and downstream migration in the summer holding and spawning reach for spring-run Chinook salmon.

## 7.3.3 Contribution to the HET

The potential contribution of the Antelope Creek Action to the HET was evaluated using the HET contribution procedure. Refer to Appendix E for a summary of the HET contribution that was determined for the Antelope Creek Action.

The reference abundance of 500 spring-run Chinook salmon in Antelope Creek was estimated as a reasonable upper threshold based on current DFG estimates (Harvey-Arrison pers. comm.). The current abundance of 50 spring-run Chinook was based on the rounded average escapement from 1999 to 2008 using data obtained from GrandTab (DFG 2009). Impaired passage was determined to be high (75%) due to the braided channel in the valley reach of Antelope Creek and Paynes Crossing, which can block passage in low-flow years.

The reference condition for spring-run Chinook in Antelope Creek includes some form of water diversion at Edwards Dam. All of the reference conditions, except water quality, were believed to be suboptimal, with some room for improvement. Because flow is the primary limiting factor in the lower portion of Antelope Creek, it was the factor with the most restoration potential.

The Antelope Creek Action would remove an instream structure at Paynes Crossing and replace it with a bridge that would span the creek. As shown in

Appendix E, improvements at Paynes Crossing could increase potential habitat for approximately 250 spring-run Chinook salmon.

## 7.3.4 Estimated Cost

### 7.3.4.1 Capital Cost

The feasibility and design studies for this action are complete. Permitting is underway and should be completed by early 2010. Based on the completed feasibility and design studies, the capital cost for implementing the Antelope Creek Action at Paynes Crossing would be a minimum of $800,000.

### 7.3.4.2 Operations and Maintenance

Because DFG would be responsible for the maintaining the bridge at Paynes Crossing, no O&M costs are associated with this action.

### 7.3.4.3 Funding Partners

AFRP funded the feasibility and design studies, as well as the permitting for this action.

## 7.3.5 Implementation Schedule

DFG is reviewing the CEQA documentation associated with construction of a bridge at Paynes Crossing. All permits should be completed and received by spring 2010. Once the permits are received and funding is secured, work could begin as early as the next instream work season (June through October 15, 2010). The Antelope Creek Action could be completed within one work season.

## 7.3.6 Implementation Responsibilities of Licensees

Once NMFS approves the final HEP, the Licensees would review the designs, permits, and CEQA documentation prepared for the Antelope Creek Action. When the Licensees accept each of the new FERC licenses for the Oroville, Poe, and Upper North Fork Feather River Projects, the Licensees would begin the final design and permitting phase. Because DFG is the only landowner at Paynes Crossing, the Licensees would consult with DFG as part of the permit review process. As soon as all of the documentation is prepared and permits are secured, the Licensees would prepare a bid package for a contractor to build the bridge.

Licensees would provide funding to DFG for maintenance of the bridge for 50 years.

## 7.3.7 Rationale for Selection

Appendix C4 presents the scoring results of applying the HEA Evaluation Criteria to the action, and Appendix C5 presents the scoring results of applying the HEA Selection Criteria to the action.

Based on the results of the HET contribution procedure, installing a bridge at Paynes Crossing could increase potential habitat for approximately 250 spring-run Chinook salmon (Appendix E). In addition, AFRP is funding several restoration projects in the valley portion of Antelope Creek to address passage issues associated with agricultural diversions and the braided channel in the lower reach of Antelope Creek. In combination, these actions would address the main factors limiting spring-run and steelhead passage in Antelope Creek.

Installing the bridge at Paynes Crossing is technically feasible, with an estimated lifespan that is equivalent to the length of the relicensing period (50 years). This action would improve volitional passage into existing habitat for both spring-run Chinook salmon and steelhead. In addition, it would allow spring-run Chinook to be spatially separated from fall-run Chinook. While Antelope Creek cannot support an independent, self-sustaining spring-run Chinook salmon population, it can support a persistent, dependent population within the existing metapopulation (Mill, Deer, and Butte Creeks). Dependent populations of Chinook salmon are important in protecting the metapopulation from catastrophic risks and contribute to the VSP concepts of abundance, productivity, spatial separation, and biological diversity.

Antelope Creek has small populations of both spring-run Chinook salmon and steelhead that could be improved by installing the bridge at Paynes Crossing. Salmon and steelhead stocks would not need to be introduced into the watershed. The Antelope Creek Action is consistent with other resource uses and could provide benefits to other anadromous and resident fish. This action is not expected to adversely affect other ESA-listed species or their habitat, or any cultural resources.

The Antelope Creek Action at Paynes Crossing is a “shovel-ready,” cost-effective action with broad support from several agencies and organizations, including DFG, USFWS, NMFS, and Tehama County RCD. The action could be implemented quickly and would immediately improve escapement of both spring-run Chinook salmon and steelhead into historical habitat. Antelope Creek is one of the few remaining watersheds where the upper portion of the watershed is relatively undisturbed and provides quality spawning and summer holding habitat for spring-run Chinook salmon and steelhead.

### 7.3.8 Other Issues

Because the Antelope Creek watershed is relatively small, this action would meet only a portion of the HET. The estimated contribution to the HET is based on historical escapement estimates from DFG. No estimate of the potential escapement based on the actual amount of spawning and holding habitat currently is available. However, AFRP has identified Antelope Creek as a high-priority stream for restoration, and no known opposition or other issues are associated with this action.

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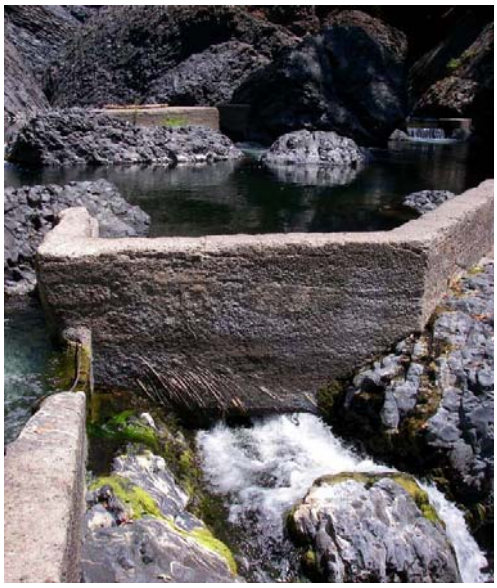
Chapter 8

# Big Chico Creek Habitat Expansion Action



Big Chico Creek photo credit:
by Jeff Sanchez, California State University, Chico.

## 8.1 Description of Habitat Expansion Actions

### 8.1.1 Background

A massive landslide in the early 1900s blocked spring-run Chinook salmon and steelhead access to historical holding and spawning habitat above Iron Canyon on Big Chico Creek. In 1958, DFG constructed the Iron Canyon fish ladder to provide access to the approximately 9 miles of habitat above Iron Canyon. The ladder is now 50 years old, and damage has made fish passage at low flows extremely difficult or impossible. Because there is no summer holding habitat below Iron Canyon, spring-run Chinook salmon that cannot pass through the ladder usually die prior to spawning.

### 8.1.2 Location

The Iron Canyon fish ladder is located in Iron Canyon, Upper Bidwell Park, on Big Chico Creek, northeast of Chico in Butte County (Figure 8-1). The site is located near Salmon Hole and Parking Lot P in Upper Bidwell Park, and is accessible from Upper Park Road.

### 8.1.3 Purpose

The Big Chico Creek Action would improve the Iron Canyon fish ladder to facilitate the upstream passage of spring-run Chinook salmon and steelhead to summer holding, spawning, and rearing habitat over a broader range of flows.

### 8.1.4 Recommended Action

The Big Chico Creek Action involves a variety of repairs to the Iron Canyon fish ladder, described in more detail below, to improve fish passage through the ladder.

### 8.1.5 Sources

Information on the Big Chico Creek Action was received from DFG and the CSU, Chico Research Foundation. Each organization submitted a completed HEA questionnaire, proposing rehabilitation of the Iron Canyon fish ladder.

## 8.2 Context for Action

### 8.2.1 Description of the Watershed

The Big Chico Creek watershed is an eastside tributary located in Butte and Tehama Counties that encompasses an area of approximately 72 square miles (USFWS 1995). The headwaters of Big Chico Creek originate from the southwest slope of Colby Mountain at an elevation of approximately 5,400 feet. Big Chico Creek is approximately 45 miles in length and enters the Sacramento River west of the City of Chico (USFWS 1995).

Big Chico Creek is a small watershed with substantial urban, agricultural, and flood control impacts in the lower watershed. Nevertheless, some portions of the valley reach still support dense riparian vegetation. Big Chico Creek runs through a steep canyon in the foothill reach up to Higgin's Hole (the uppermost limit for salmon and steelhead). The canyon narrows upstream from Higgin's Hole and the watershed is relatively pristine (CH2M Hill 1998). The amount of available spawning and holding habitat for spring-run Chinook salmon and steelhead in Big Chico Creek is essentially the same as historical conditions.

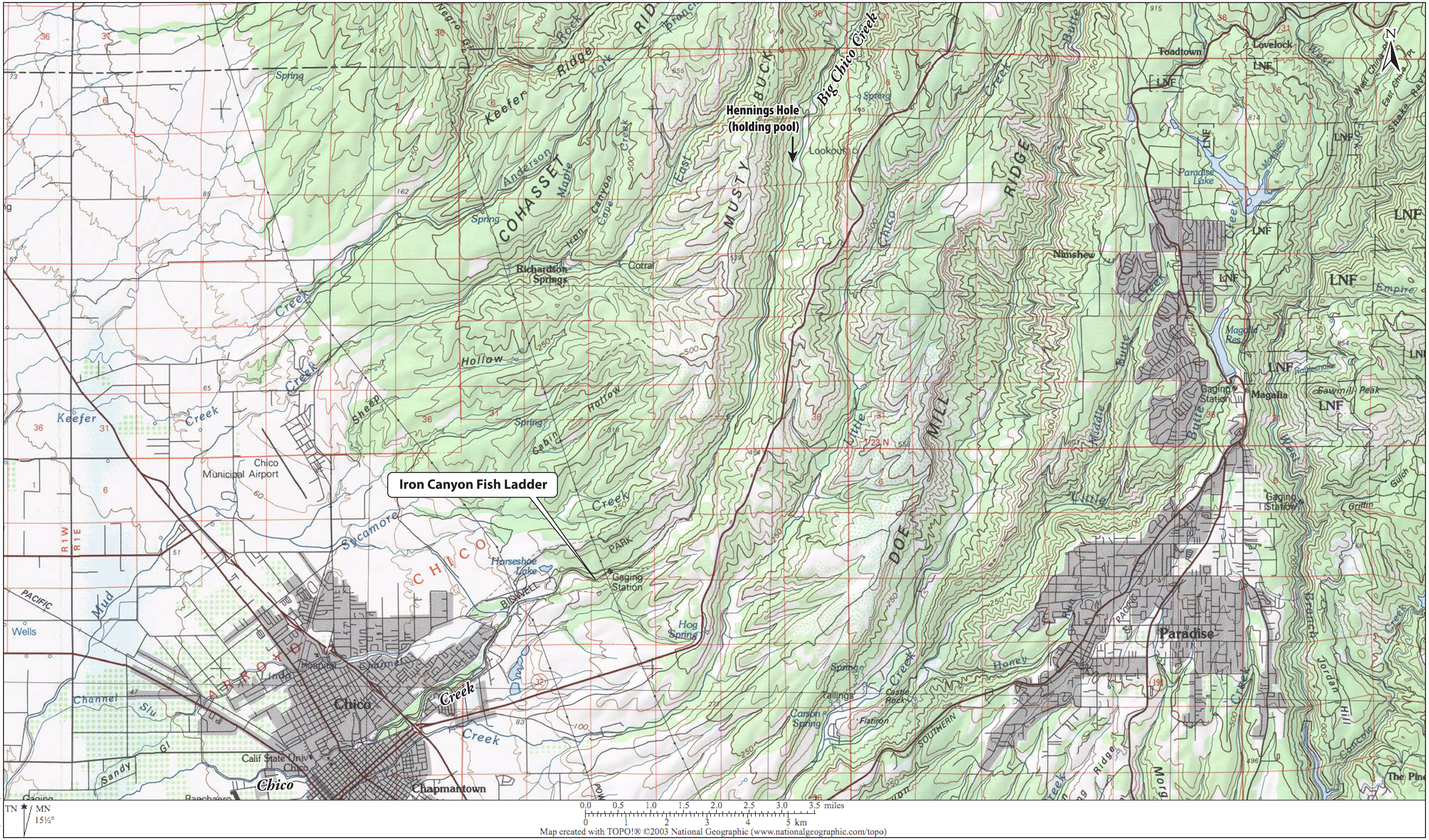



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**Figure 8-1**
**Big Chico Creek Action - Iron Canyon Fish Ladder**

## 8.2.2 Status of Spring-Run Chinook Salmon and Steelhead Runs

### 8.2.2.1 Spring-Run Chinook Salmon

Historically, Big Chico Creek supported a small run (up to 1,000 fish) of spring-run Chinook salmon, but a viable population is no longer believed to exist (CH2M Hill 1998). Lindley et al. (2004) characterized the population as dependent upon migrants from other populations for its existence. In recent years, the population has ranged from 0 to 200 fish.

Because of the relatively low abundance and sporadic annual escapement of spring-run Chinook salmon, the extinction risk for this dependent population is high (Lindley et al. 2007). Implementation of key recovery actions could improve conditions to reduce the risk of extinction. See Appendix D for more information on the status of spring-run Chinook salmon in Big Chico Creek.

### 8.2.2.2 Steelhead

Big Chico Creek most likely was opportunistically used in the past by steelhead (Yoshiyama et al. 1996). Although population abundance data are not available, Big Chico Creek is believed to support a small population of steelhead. It is characterized as having a low to moderate potential to support a viable population of steelhead (Lindley et al. 2007). See Appendix D for more information on the status of steelhead in Big Chico Creek.

## 8.2.3 Limiting Factors

Low flows, mainly due to agricultural diversions, and high water temperatures are the primary limiting factors in Big Chico Creek for spring-run Chinook salmon and steelhead (BCCWA 2006). Low flows affect passage for both adults and juveniles, and contribute to increased water temperatures. Passage for adults to suitable holding and spawning habitat upstream of Iron Canyon fish ladder is also limited by the damaged ladder. Additionally, loss of riparian habitat in the valley reach and diversion by flood control structures limit salmonid production (BCCWA 2006).

# 8.3 Iron Canyon Fish Ladder Rehabilitation

## 8.3.1 Description

The Big Chico Creek Action would repair, expand, or modify existing weirs and install six new weirs at the Iron Canyon fish ladder. Construction involves deepening pools, excavating pool sidewalls, partial or complete removal of boulder-size blocks, partial demolition of 18 existing weirs, installing new weirs, and installing fabricated aluminum flashboards.

## 8.3.2 Objectives and Benefits

Rehabilitating the Iron Canyon fish ladder would allow the ladder to function effectively over a broader range of flow, facilitating the upstream passage of spring-run Chinook salmon and steelhead. By facilitating fish passage, this action would help increase escapement and provide access to additional juvenile rearing habitat for both spring-run Chinook salmon and steelhead.

## 8.3.3 Contribution to the HET

The potential contribution of the Big Chico Creek Action was evaluated using the HET contribution procedure. Refer to Appendix E for a summary of the HET contribution that was determined for the action.

The reference abundance of 1,000 spring-run Chinook salmon in Big Chico Creek was estimated as a reasonable upper threshold based on DFG estimates (McReynolds pers. comm.). The current abundance was estimated to be 50 spring-run Chinook salmon based on the rounded average escapement from 1999 to 2008 using data from GrandTab (DFG 2009). Passage impairment is high (75%) due to a combination of flood control weirs and the Iron Canyon fish ladder, which blocks fish passage in low-flow years.

The reference condition for spring-run Chinook salmon in Big Chico Creek included the concrete swimming pool in Bidwell Park, flood channels, and the cascade of water at the upstream extent of migration. Given these constraints, the reference condition was significantly less than optimal for many of the habitat factors. However, with the exception of temperature, it was determined that there was room for improvement in all of the habitat conditions. Since the only action under consideration for this action is the rehabilitation of the Iron Canyon fish ladder, passage was the only condition evaluated. As shown in Appendix E, improvements at the Iron Canyon fish ladder could increase potential habitat for approximately 500 spring-run Chinook salmon.

## 8.3.4 Estimated Cost

### 8.3.4.1 Capital Cost

The feasibility and design studies for this action are complete, and permitting is anticipated to be completed by December 2009. HDR (2007) estimated that repairing the Iron Canyon fish ladder would cost approximately $1.7 million. Adjusting the amount for 2010 construction costs and adding expenses for grant administration, public outreach, and an extended construction period to allow for concrete curing increase the total capital cost to approximately $2.2 million.

### 8.3.4.2 Operations and Maintenance

DFG has an agreement with the City of Chico and CSU, Chico Research Foundation to continue basic O&M activities for the fish ladder, but the Licensees would be responsible for activities beyond basic O&M such as repairs or necessary structural changes to ensure that the ladder functions as designed. Basic O&M activities include removing accumulated debris and sediment from pools, installing/removing flashboards, and monitoring movement or deterioration of the fish ladder.

### 8.3.4.3 Funding Partners

AFRP funded the feasibility and design studies for rehabilitation of the Iron Canyon fish ladder. CSU, Chico Research Foundation has acquired all of the necessary permits, and the City of Chico has completed an Initial Study/Mitigated Negative Declaration for the action (CSU 2008).

## 8.3.5 Implementation Schedule

Only one Corps permit for this action is outstanding and should be finalized by the end of the year (December 2009). Once the permits are received and funding is secured, work could begin as early as the next instream work season (June through October 15, 2010). Repairs to the Iron Canyon fish ladder could be completed within one work season.

## 8.3.6 Implementation Responsibilities of Licensees

Once NMFS approves the final HEP, the Licensees would review the designs, permits, and CEQA documentation prepared for the Big Chico Creek Action. When the Licensees accept each of the new FERC licenses for the Oroville, Poe,

and Upper North Fork Feather River Projects, the Licensees would begin the final design and permitting phase. Because the City of Chico is the only landowner associated with the Iron Canyon fish ladder, the Licensees would be consulting with the City as part of the permit review process. As soon as all of the documentation is prepared and permits are secured, the Licensees would prepare a bid package for a contractor to repair the fish ladder. Licensees would provide funding to DFG or another entity for maintenance of the fish ladder to ensure that it functions as designed for 50 years.

## 8.3.7 Rationale for Selection

Appendix C4 presents the scoring results of applying the HEA Evaluation Criteria to the action, and Appendix C5 presents the scoring results of applying the HEA Selection Criteria to the action.

Based on the estimated contribution to the HET, repairing the Iron Canyon fish ladder could increase potential habitat for approximately 500 spring-run Chinook salmon (Appendix E). Numerous other restoration projects are ongoing in Big Chico Creek to address fish passage issues associated with agricultural diversions and flood control structures in the lower portion of the watershed. In addition, the Big Chico Creek Watershed Alliance (BCCWA) is implementing a "bio-technical" streambank stabilization project, a gravel mining site restoration project, and a non-native plant eradication project in the lower reaches of Big Chico Creek.

Repairing the Iron Canyon fish ladder is technically feasible with an estimated lifespan that is equivalent to the length of the relicensing period (50 years) and requires only minimal annual O&M. This action would improve volitional passage into existing habitat for both spring-run Chinook salmon and steelhead. In addition, it allows spring-run Chinook salmon to be spatially separated from fall-run Chinook.

While Big Chico Creek cannot support an independent, self-sustaining spring-run Chinook salmon population, it can support a persistent, dependent population within the existing metapopulation (Mill, Deer, and Butte Creeks). Dependent populations of Chinook salmon are important in protecting the metapopulation from catastrophic risks and contribute to the VSP concepts of abundance, productivity, spatial separation, and biological diversity.

Big Chico Creek already has small populations of both spring-run Chinook salmon and steelhead, which could be improved by repairing the Iron Canyon fish ladder. Salmon and steelhead stocks would not need to be introduced into the watershed. Although rehabilitation of the Iron Canyon fish ladder is consistent with other resource uses, it will not necessarily provide benefits to other anadromous and resident fish given the location and type of the action being implemented. The action is not expected to adversely affect other ESA-listed species or their habitat, or any cultural resources.

Rehabilitation of the Iron Canyon fish ladder is a "shovel-ready," cost-effective action with broad support from several agencies and organizations, including DFG, USFWS, BCCWA, and CSU, Chico Research Foundation. The action could be implemented quickly and would immediately improve escapement of both spring-run Chinook salmon and steelhead into historical habitat. Additionally, the action would result in a moderate contribution to the HET, making it a solid component of the HEP.

### 8.3.8 Other Issues

Conditions in lower Big Chico Creek may be a small drawback to rehabilitation of the Iron Canyon fish ladder. One-Mile and Five-Mile Dams were identified as possible fish passage impediments in the NMFS Public Draft Recovery Plan. However, it is unlikely that either dam is a significant passage impediment for spring-run Chinook salmon or steelhead (McReynolds pers. comm.). Juvenile salmonids could be stranded in Lindo Channel as flows recede, but stranding is not expected to occur in large numbers (McReynolds pers. comm.). No known opposition or other issues are associated with this action.

The estimated contribution to the HET is based on historical escapement estimates from DFG. No estimate of the potential escapement based on the actual amount of spawning and holding habitat is currently available.

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Chapter 9

# Battle Creek Habitat Expansion Actions

Battle Creek photo credit:
by U.S. Bureau of Reclamation 2005.

## 9.1 Description of Habitat Expansion Actions

### 9.1.1 Background

The signatories to a 1999 Memorandum of Understanding (MOU)—Reclamation, USFWS, NMFS, DFG, and PG&E—are engaged in the Battle Creek Salmon and Steelhead Restoration Project (Battle Creek Restoration Project). The project presents an opportunity to reestablish approximately 42 miles of prime salmon and steelhead habitat on Battle Creek, plus an additional 6 miles of habitat on its tributaries. Restoration would be accomplished primarily through modification of the Battle Creek Hydroelectric Project (FERC Project No. 1121) facilities and operations, including instream flow releases.

The Battle Creek Restoration Project consists of three phases: Phase 1A, Phase 1B, and Phase 2. Phase 1A includes actions that are primarily on North Fork Battle Creek, Phase 1B includes actions at a single site on the lower South Fork of Battle Creek, and Phase 2 is focused on South Fork Battle Creek and its tributaries.

The main components of Phase 1A include construction of fish ladders and screens at North Fork Battle Creek Feeder Diversion Dam and Eagle Canyon Diversion Dam; removal of Wildcat Diversion Dam; increased flows and a downstream fish barrier at Asbury Pump Station and Diversion Dam on Baldwin Creek; replacement of a portion of Eagle Canyon Canal with a pipeline to prevent mixture of Battle Creek water with Mount Lassen Trout Farm's water supply; and a post-construction increase in instream flow releases on North Fork

Battle Creek. The components of Phase 1B include construction of a tailrace connector and bypass for Inskip Powerhouse at Coleman Diversion Dam. The main components of Phase 2 include construction of a fish screen and fish ladder at Inskip Diversion Dam; construction of a tailrace connector for South Powerhouse at Inskip Diversion Dam; removal of South, Soap Creek Feeder, Lower Ripley Creek Feeder, and Coleman Diversion Dams; and decommissioning of South Canal; and a post-construction increase in instream flow releases on the South Fork Battle Creek.

Construction of Phase 1A and Phase 1B has been funded and is scheduled to begin in 2010, whereas the start of construction for Phase 2 has yet to be determined because full funding has not been secured. The Battle Creek Habitat Expansion Actions (Battle Creek Actions) under this draft HEP focus on selected components of Phase 2, namely the construction of the fish screen and ladder at Inskip Diversion Dam, construction of a tailrace connector from South Powerhouse to Inskip Canal, the removal four diversion dams, and the decommissioning of South Canal, as described below under "Habitat Expansion Actions."

## 9.1.2 Location

The Battle Creek Actions are located on the South Fork of Battle Creek in Tehama County, several miles southwest of the town of Manton. Battle Creek Actions include five main project sites on South Fork Battle Creek (Figure 9-1):

- Coleman Diversion Dam,
- Lower Ripley Creek Feeder Diversion Dam,
- Inskip Diversion Dam/South Powerhouse,
- Soap Creek Feeder Diversion Dam, and
- South Diversion Dam and South Canal.

## 9.1.3 Purpose

The purpose of the Battle Creek Restoration Project is to restore approximately 16 miles (Kier Associates 1999) of salmonid habitat in South Fork Battle Creek while minimizing the loss of clean and renewable electric energy produced by the hydroelectric facilities. The Battle Creek Actions also support this purpose.

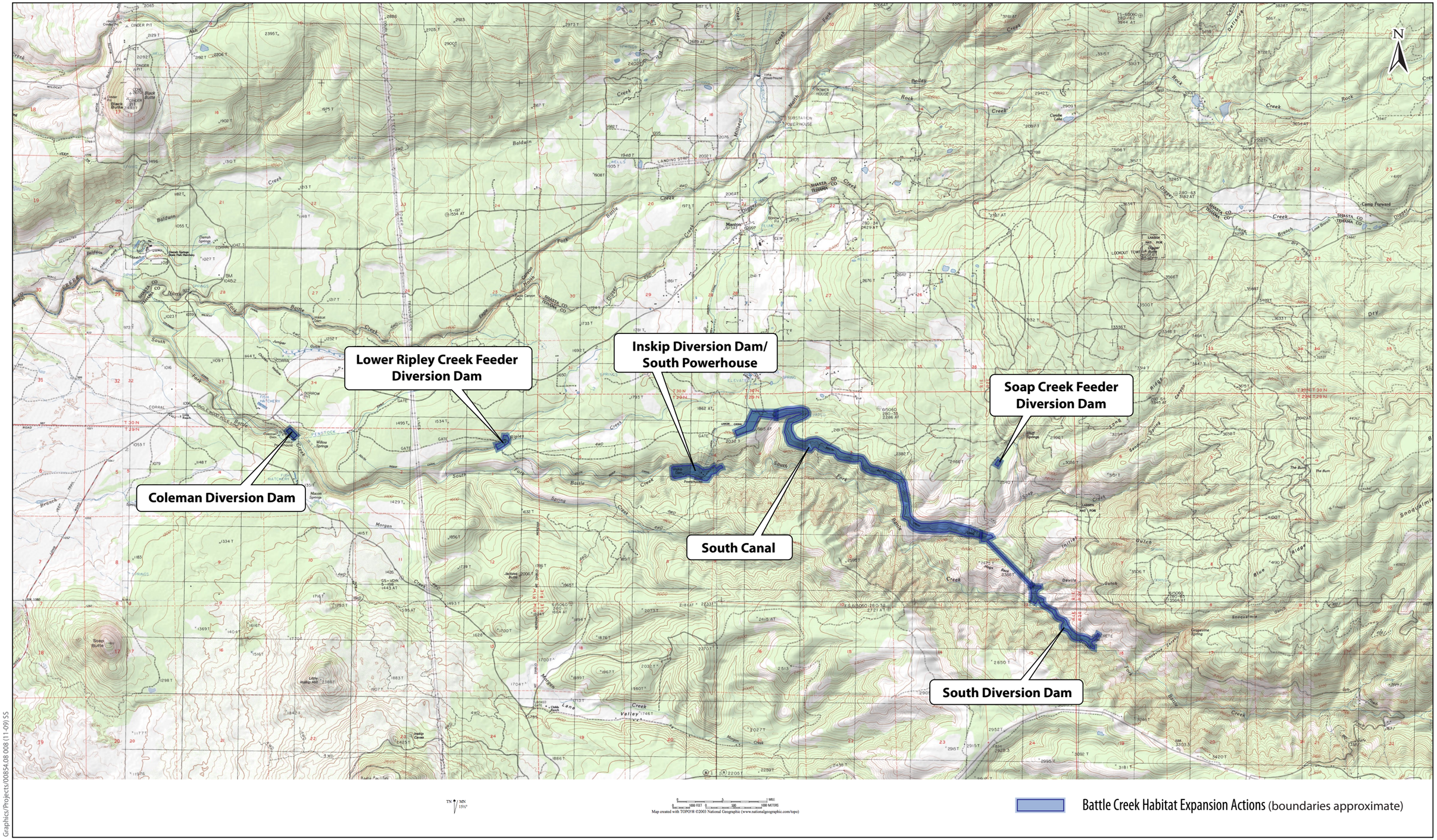


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**Figure 9-1**
**Battle Creek Habitat Expansion Actions**

### 9.1.4 Recommended Actions

The Battle Creek Actions include only selected actions from Phase 2 of the Battle Creek Restoration Project as follows:

- installing fish screens and fish ladders on Inskip Diversion Dam;
- installing a tailrace connector from South Powerhouse to Inskip Canal;
- removing South, Lower Ripley Creek Feeder, Soap Creek Feeder, and Coleman Diversion Dams; and
- decommissioning South Canal.

Instream flows would increase because of the dam removals on South Fork Battle Creek and its tributaries. Additionally, under the MOU for the Battle Creek Restoration Project, PG&E will increase instream flow releases from Inskip Diversion Dam post construction. The cost of the increased instream flow releases and transference of water rights are the post-construction responsibility of PG&E; this cost is not included in the estimated cost of the Battle Creek Restoration Project, and were not included in the Battle Creek Actions

### 9.1.5 Sources

The main sources of information used in evaluating the Battle Creek Actions include the HEA questionnaire received from DFG (Appendix F4), the Final EIS/EIR for the Battle Creek Restoration Project (Jones and Stokes 2005), and the Battle Creek Salmon and Steelhead Restoration Plan (Kier Associates 1999). Other sources of information included various published and unpublished works and personal communications.

## 9.2 Context for Action

### 9.2.1 Description of the Watershed

Battle Creek drains a watershed of approximately 357 square miles in the southern Cascade Range of the northern Central Valley and flows into the Sacramento River at RM 272, approximately 5 miles east of the town of Cottonwood, California. Battle Creek and its tributaries drain the western volcanic slopes of Mount Lassen, which is located at the eastern edge of the watershed. The large snowfields on this 10,000-foot peak maintain streamflow until late in summer. The volcanic formations and alluvial stream channels buried by lava flows store most of the wet season rainfall and convey it to the streams and numerous springs as year-round cold base flows.

Battle Creek is composed of two main branches: North Fork Battle Creek and South Fork Battle Creek. North Fork Battle Creek, which is approximately

29.5 miles long from its headwaters to the confluence, drains a basin of approximately 213 square miles. South Fork Battle Creek, which is approximately 28 miles long from its headwaters to the confluence, drains a basin of approximately 124 square miles. The mainstem valley reach of Battle Creek flows approximately 17 miles from the confluence of its forks to the Sacramento River. Coleman National Fish Hatchery (CNFH) is located at Battle Creek RM 7.5.

Battle Creek has the largest base flow or dry-season flow of any of the tributaries to the Sacramento River between the Feather River and Keswick Dam. The spring-fed nature of Battle Creek results in an average September flow of 255 cfs reaching the Sacramento River from the Battle Creek drainage area.

## 9.2.2 Status of Spring-Run Chinook Salmon and Steelhead Runs

### 9.2.2.1 Spring-Run Chinook Salmon

The escapement of spring-run Chinook salmon in Battle Creek varied between 500 and 2,000 fish from the mid 1940s to the late 1950s (Campbell and Moyle 1991). Abundance declined sharply after this period and ranged from zero to less than 10 fish in the 1980s (Campbell and Moyle 1991, DFG 2009). Recent years have seen a modest increase in the number of returning spring-run Chinook salmon to Battle Creek, with an average of 115 fish per year between 1999 and 2008 and a maximum of almost 300 fish in 2007 (DFG 2009). Spring-run Chinook salmon have been extirpated from reaches above impassable dams in Battle Creek, and the population as a whole is intermittent and not viable.

The most recently published data on the distribution of Chinook salmon in Battle Creek indicate that many spring-run Chinook salmon spend the summer holding in two large pools in the lower portion of South Fork Battle Creek and in the mainstem below the confluence of the North and South Forks (Newton et al. 2007). From 2001 to 2006, an average of 64 live spring-run Chinook salmon were observed each year in Battle Creek during August, of which 9% were in the North Fork, 36% in the South Fork, and 55% in the mainstem (Newton et al. 2007). Of an annual average of 82 observed redds during August through November from 2001 to 2006, Newton et al. (2007) found an average of 50% in the North Fork, 19% in the South Fork, and 31% in the main stem of Battle Creek.

### 9.2.2.2 Steelhead

From 1967 to 1993, the estimated number of steelhead passing Red Bluff Diversion Dam ranged from a low of 470 to a high of 19,615 (DFG 1994, 1996). While estimates vary, perhaps 10% of these fish spawned in Battle Creek and

approximately 28% were believed to have spawned at the CNFH (USFWS 1984). From 1996 onward, adult steelhead, both wild and of hatchery origin, were allowed to pass the CNFH weir (Jones & Stokes 2005). Recent estimates of the number of wild steelhead passing upstream of the CNFH weir during October through February averaged almost 280 fish per year from 2000 to 2006 (Newton et al. 2007). Concerns over the potential negative effects of hatchery-origin fish on wild fish resulted in a policy change: hatchery-origin steelhead are no longer allowed to pass over the weir (Newton et al. 2007).

### 9.2.3 Limiting Factors

In the early 1900s, several dams were built on Battle Creek as part of a hydroelectric power production project. The dams on South Fork Battle Creek diverted a majority of the water out of this tributary and blocked passage of adult spring-run Chinook salmon and steelhead. Diversions for hydropower reduced the flow in South Fork Battle Creek to 5 cfs, thus severely limiting habitat for all life stages of spring-run Chinook salmon and steelhead (Appendix F4). Because of the reduced flow, water temperatures increased to levels lethal to all life stages of spring-run Chinook salmon and steelhead. Since 1999, interim flow releases (30 cfs) under the restoration effort on the South Fork below Coleman Diversion Dam have improved conditions in the reach below the dam. Because the fish ladders on the diversion dams are too small or are in poor condition, they block access for spring-run Chinook salmon and steelhead to approximately 16.3 miles of prime habitat.

## 9.3 Battle Creek Habitat Expansion Actions

### 9.3.1 Description

As explained above under *Recommended Actions*, the Battle Creek Actions include only selected actions from Phase 2 of the Battle Creek Restoration Project including the installation of fish screens and fish ladders on Inskip Diversion Dam; installation of a tailrace connector from South Powerhouse to Inskip Canal; removal of South, Lower Ripley Creek Feeder, Soap Creek Feeder, and Coleman Diversion Dams; and decommissioning of South Canal. Each of the construction/decommissioning actions is briefly described below.

### 9.3.1.1 Fish Screen and Fish Ladder at Inskip Diversion Dam

The proposed fish screen and ladder would improve fish passage at Inskip Diversion Dam and flow diversion to the Inskip Canal. The proposed Half Ice Harbor fish ladder would be located on the north (right) bank of South Fork Battle Creek below Inskip Diversion Dam. The exit pool of the fish ladder would be located immediately downstream of the fish screen and adjacent to the gate structure on Inskip Canal, and video monitoring equipment would be installed at the outlet pool for biological monitoring. A bypass channel would be provided to divert water around the fish screen, if needed. Metalwork from the existing Alaska Steeppass fish ladder would be removed, and the concrete portion of the original pool and weir ladder would remain in place, but the upper end would be blocked so that upstream migrants are no longer attracted to the ladder.

The proposed 122-foot-long flat plate fish screen would be constructed in Inskip Canal extending downstream from a point beginning about 190 feet below the diversion headworks. The capacity of the proposed fish screen would be 220 cfs under normal operating conditions. The water depth on the screen would be maintained at 6 to 7 feet depending on the creek stage, and the base of the screen would be set 6 inches above the canal bottom to allow for some sediment collection without affecting the screen operation. The screen would be equipped with stage sensors on both sides of the screen to measure head differential. If a problem is detected, the sensors would trigger an activation of the screen-cleaning mechanism (motorized sweeping brushes), and/or send an alarm. If the problem continues, the diversion would be shut down.

Coordinated hydraulic control of the fish screen and ladder would be accomplished with the use of a series of vertical sliding gates located in the canal. Sensors would be included in the ladder to allow automatic operation of the control gates during high flows. Other sensors would be incorporated into the ladder and fish screen to ensure that minimum instream flow requirements are met.

### 9.3.1.2 Tailrace Connector from South Powerhouse to Inskip Canal

A tailrace connector tunnel would be constructed from South Powerhouse to Inskip Canal, to allow diversion of South Powerhouse tailrace flows to the canal. The connector tunnel consists of a new 1,200-foot-long tunnel that would be excavated in the northern slope paralleling South Fork Battle Creek. The tailrace channel immediately upstream of the inlet portal to the connector tunnel would include a sediment trap basin. The tunnel outlet portal discharges flows into the Inskip Canal at a point approximately 150 feet upstream of the inlet portal of Tunnel No. 2 on Inskip Canal. The connector tunnel design discharge is 165 cfs. The tunnel, with a height/diameter of 10 feet, would be unlined, except for some

short sections that may require shotcrete lining (shotcrete is a form of pneumatically applied concrete).

### 9.3.1.3 Decommissioning of South Canal

The metal canal flume sections along South Canal, as well as other miscellaneous metalwork, would be disassembled and bundled for removal by helicopter. The reinforced concrete flume footings generally would be left in place; however, some footings that are visible from South Fork Battle Creek would be removed and disposed of offsite. Pursuant to landowner discussions, the tunnel sections along South Canal would be abandoned through sealing, filling in, and/or installing of angle iron gates in a manner that would allow the tunnels to serve as bat habitat but prevent people from entering. Tunnel sections that would not be useful as bat habitat (because of their small size and short length) may be caved in (or collapsed) for safety reasons.

### 9.3.1.4 Dam Removals

#### South Diversion Dam

South Diversion Dam and all appurtenant facilities would be completely removed. The gravel and cobble material filling the bins behind the dam would be removed and spread downstream of the dam over a distance of approximately 300 feet. The material would be placed along and within the creek channel in a manner that would not hinder flows or fish passage. All concrete would be removed from the stream channel; however, concrete not containing steel may be broken up into 1- to 2-foot size fragments and buried in portions of South Canal.

#### Soap Creek Feeder Diversion Dam

Soap Creek Feeder Diversion Dam and all appurtenant facilities would be removed to the existing streambed grade. Dam materials not containing steel would be broken up into pieces no larger than 1 to 2 feet in size, hauled to the nearest South Canal open-channel site, and buried. The dam retains a minor volume of sediments. A pilot channel would not need to be excavated because natural creek flows would be sufficient to distribute the materials downstream. Cold spring water entering Soap Creek above the dam would be allowed to continue downstream of the dam site.

#### Lower Ripley Creek Feeder Diversion Dam

Lower Ripley Creek Feeder Diversion Dam and all appurtenant facilities would be removed. The diversion dam is a very small structure that could be removed easily using an excavator with a hoe-ram or similar construction equipment. All

waste concrete would be removed from the site. Cold spring water entering Ripley Creek above the dam would be allowed to continue downstream of the dam site.

### Coleman Diversion Dam

Coleman Diversion Dam and all appurtenant facilities would be removed. The radial pass-through gate structure, the Alaska Steeppass fish ladder and concrete, and the original concrete fish ladder structure also would be removed.

## 9.3.2 Objectives and Benefits

### 9.3.2.1 Objectives

Completion of the Battle Creek Actions would increase instream flow, improve temperature, and provide access to 16.3 miles of prime historical spring-run Chinook salmon and steelhead habitat. The Battle Creek Actions also would restore optimum water temperatures for egg incubation, juvenile rearing, and outmigrating smolts; screening the diversions would prevent entrainment of emigrating juveniles.

### 9.3.2.2 Benefits

Phase 2 of the Battle Creek Restoration Project would provide benefits to several key components of the South Fork Battle Creek habitat that would also be realized by implementing the Battle Creek Actions. When the Battle Creek Restoration Project is completed, instream flow releases would be increased downstream of Inskip Diversion Dam from the current 5 cfs to a range of 40−86 cfs. Upstream of Inskip Diversion Dam, the flows would increase to natural magnitudes because of removal of South Diversion Dam. Increased flows would lower the temperatures in Battle Creek to levels capable of supporting all life stages of spring-run Chinook salmon and steelhead. Removal of two smaller dams (Soap Creek Feeder and Lower Ripley Creek Feeder Diversion Dams) and a new fish ladder at Inskip Diversion Dam would allow access to 16.3 miles of prime spring-run Chinook salmon and steelhead habitat that has not been used since the early 1900s, when the hydroelectric projects were first built. Construction of a state- and federally approved fish screen at Inskip Diversion Dam would allow safe passage of emigrating juveniles. As a secondary benefit, the increased flow and additional nutrients from decaying salmon carcasses may enhance growth of adjacent riparian forest/vegetation along the banks of South Fork Battle Creek.

In addition to supporting spring-run Chinook salmon and steelhead, implementing the Battle Creek Restoration Project (one of the largest anadromous fish restoration efforts in North America) could benefit other fish

species native to Battle Creek, including residents such as rainbow trout and migrants such as winter-run Chinook salmon and Pacific lamprey.

## 9.3.3 Contribution to the HET

According to the Battle Creek Restoration Plan (Kier Associates 1999) and DFG (Appendix F4), Phase 2 of the Battle Creek Restoration Project could provide access to habitat for 1,250 to 2,500 spring-run Chinook salmon and from 500 to 1,000 steelhead. The estimates for spring-run Chinook salmon provided by Kier Associates (1999) and DFG (Berry pers. comm.) are consistent with estimates resulting from application of the HET contribution procedure to the Battle Creek Actions. Refer to Appendix E for a summary of the contribution to the HET that was determined for the Battle Creek Actions.

The current abundance of spring-run Chinook salmon in South Fork Battle Creek was estimated to be 40. Because specific escapement estimates for Battle Creek are basinwide (DFG 2009), an estimate was needed for the escapement for the South Fork. This was calculated as one-third of the rounded average escapement estimates for the Battle Creek system from 1999 to 2008; the calculation reflects that the usable areas of habitat for spring-run Chinook salmon are approximately equal in the North Fork, South Fork, and mainstem Battle Creek. The reference abundance of 2,000 fish was estimated based on a combination of sources, including AFRP goals (USFWS 1995); direct comparisons between the gravel availability specified in the Final EIS/EIR (Jones & Stokes 2005) (i.e., approximately 13,100 square miles watershed-wide) and comparisons with Butte Creek gravel availability (approximately 15,100 square miles); the HEA questionnaire prepared by DFG, which indicates a range of 1,250 to 2,500 fish (Appendix F4); and historical estimates ranging from 1,700 to 2,200 fish (between 1952 and 1956).

Spawning overlap between spring-run and fall-run Chinook salmon was assumed to be absent in this watershed because of both natural segregation and intentional blockage of fall-run Chinook salmon at the CNFH weir. Passage impairment was estimated to be 85% based on the existence of a number of dams and the current management of the barrier weir ladder at CNFH (i.e., selective passing of spring-run Chinook). The reference condition in Battle Creek is assumed to include some degree of continued water diversion for power generation. Inskip Diversion Dam is set to remain in place once project construction is complete so it was determined to be a “permanent” constraint. The majority of the habitat attributes are in good condition; therefore, there was little room for habitat improvement. For example, the existing dams do not retain gravels or woody debris, and the channel form has been relatively unchanged. Consequently, the three associated habitat attributes—channel form, substrate, and structure—cannot be altered and would not be expected to increase habitat potential for spring-run Chinook salmon.

In the South Fork Battle Creek, only two attributes possess appreciable opportunity for habitat change: channel unit type and flow. Channel unit type

(e.g., riffle-pool structure) has been somewhat altered due to the flow regime resulting from the power generation projects on Battle Creek. Flow has been greatly reduced and is the most altered attribute examined in the analysis. Determining the contribution to the HET from the Battle Creek Actions focused on the two primary components: fish passage improvements and flow. Nearly all of the dams on South Fork Battle Creek would be removed, with one dam being left in place and retrofitted with a fish ladder. If designed to current standards, the fish ladder would meet 95% passage efficiency. Two dam removals (Soap Creek Feeder and Lower Ripley Creek Feeder Diversion Dams) are intended primarily to provide flow benefits rather than improved fish passage; the increased flows are likely to be approximately 80% of unimpaired levels.

The Battle Creek Actions offer the second highest contribution to the HET in a single watershed after the Lower Yuba River Actions. The results of the HET contribution procedure suggest that the potential increase in habitat could support approximately 1,600 spring-run Chinook salmon in South Fork Battle Creek. Improved passage was estimated to contribute over 95% of the potential increase in numbers (Appendix E).

## 9.3.4 Estimated Cost

### 9.3.4.1 Capital Cost

The cost of Phase 2 of the Battle Creek Restoration Project is estimated at approximately $47 million. DFG could potentially fund $12 million of the total cost, which leaves approximately $35 million of funding yet to be secured. Prior to submitting a final HEP, the Licensees will consult with the signatories of the Battle Creek Restoration Project MOU concerning additional partners for full funding of Phase 2. After the remaining funds needed to complete Phase 2 have been secured, the Licensees would provide up to a $16.9 million contribution pursuant to the cost sharing provisions agreed to by DWR and PG&E for implementation of the HEA. Consistent with those provisions, PG&E will be the performing party for construction of capital improvements associated with the $16.9 million contribution. In order to provide consistency and continuity in construction of capital improvements for all of Phase 2, the Licensees favor PG&E's role as the performing party for construction of all Phase 2 capital improvements.

### 9.3.4.2 Operations and Maintenance

As owner of the Battle Creek Hydroelectric Project, PG&E would operate and maintain all of the improvements and related hydropower facilities, and has agreed to maintain them in working order. The O&M costs, including the increased instream flows post construction, would be borne by PG&E under the

terms of the MOU and would not require funding under the HEA. Separate funding provisions also have been made for ongoing adaptive management that would ensure the continued success of the restoration effort.

#### 9.3.4.3 Funding Partners

Other potential funding partners include DFG, California Wildlife Conservation Board, DWR, PG&E, and/or Reclamation.

### 9.3.5 Implementation Schedule

If funded, construction of Phase 2 could begin as early as 2011 and would take from 2 to 4 years to complete. All permitting and design are essentially complete except for a license amendment from FERC. Environmental benefits are expected to be realized immediately upon completion of construction. Biological benefits would begin in the first winter and spring after project completion, with the full benefits occurring after several generations of returning Chinook salmon and steelhead. Spring-run Chinook salmon and steelhead are present in the drainage downstream of Coleman Diversion Dam and are expected to occupy the newly opened habitat during the first adult migration period after completion.

### 9.3.6 Implementation Responsibilities of Licensees

After NMFS approves the final HEP and the Licensees accept each of the new FERC licenses for the Oroville, Poe, and Upper North Fork Feather River Projects, the Licensees plan on entering into an agreement with the Battle Creek Restoration Project MOU partners as necessary to contribute funds for construction of Phase 2 of the Battle Creek Restoration Project. Prior to submitting a final HEP, the Licensees will consult with the signatories of the Battle Creek Restoration Project MOU concerning additional partners for full funding of Phase 2. After the remaining funds needed to complete Phase 2 have been secured, the Licensees would provide up to a $16.9 million contribution pursuant to the cost sharing provisions agreed to by DWR and PG&E for implementation of the HEA. Consistent with those provisions, PG&E will be the performing party for construction of capital improvements associated with the $16.9 million contribution. In order to provide consistency and continuity in construction of capital improvements for all of Phase 2, the Licensees favor PG&E's role as the performing party for construction of all Phase 2 capital improvements.

Once construction of Phase 2 is completed, PG&E would operate and maintain all of the improvements and related hydropower facilities for the remainder of the term of the current FERC license and any subsequent license renewals by PG&E.

Separate funding provisions also are stipulated in the MOU for ongoing adaptive management that will ensure the continued success of the restoration effort**.**

## 9.3.7 Rationale for Selection

Appendix C4 presents the scoring results when the HEA Evaluation Criteria were applied to Battle Creek Actions, and Appendix C5 presents the scoring results when the HEA Selection Criteria were applied to the Battle Creek Actions.

Based on applying the HET contribution procedure, the Battle Creek Actions could increase potential habitat for approximately 1,600 spring-run Chinook salmon in South Fork Battle Creek (Appendix E).

The actions are technically feasible, as demonstrated by the existing feasibility studies (Jones & Stokes 2005). Engineering and design of the actions are largely complete, and nearly all relevant environmental documents have been finalized. The actions are therefore very close to being implemented and could be completed within a few years. Benefits would occur immediately and would continue to grow as fish populations are restored. The estimated lifespan of the actions would cover the period to any subsequent FERC relicensing and operations and maintenance are accounted for.

The Battle Creek Actions would improve access into several miles of contiguous existing habitat for both spring-run Chinook salmon and steelhead, and would encourage natural spatial separation of spring-run Chinook from fall-run Chinook in Battle Creek. The actions primarily improve volitional fish passage and, therefore, would not require substantial human intervention once construction has been completed. Completing the Battle Creek Actions would provide access to sufficient habitat to support an independent, self-sustaining spring-run Chinook salmon population. In the context of the Central Valley spring-run Chinook salmon ESU, restoration of an independent population of spring-run Chinook salmon in Battle Creek would increase the spatial coverage of the ESU and decrease the threat from catastrophic events that could affect the population in one or more watersheds. Because both spring-run Chinook salmon and steelhead already exist in Battle Creek, Battle Creek Actions would augment these populations by increasing the amount of available habitat.

Although the actions are not expected to adversely affect other ESA-listed species or their habitat, adverse effects to historical and cultural resources may occur. These have been addressed in the permitting process. Some of the diversion dams on South Fork Battle Creek that would be modified or removed are eligible for listing under the National Historic Preservation Act. The actions are consistent with other resource uses such as water supply, public safety, flood control, recreation, and power production and has a broad base of agency, local, and political support.

# 9.3.8 Other Issues

## 9.3.8.1 Eligibility

As noted, the HEA allows for a variety of actions to be considered eligible for inclusion in the HEP. Actions identified in other venues, including unfunded actions, are acceptable for consideration, provided their implementation results in a net expansion of habitat over any existing requirements and commitments. These are defined in Section 3.2 of the HEA and may include, but are not limited to, legal or regulatory requirements subject to a binding order, action by an agency or court, relicensing proceedings, or biological opinions.

The Battle Creek Restoration Project is a cooperative effort by the signatories of a 1999 MOU. As stated in Section 1.4 of the MOU, it is a voluntary partnership between the state and federal agencies, including NMFS; third-party donors; and PG&E. Currently, FERC has issued an Order to Construct Phase 1A of the Battle Creek Restoration Project and funding has been secured. Submittal of a license amendment application is imminent for Phase 1B since funding has been secured for this phase through the American Recovery and Reinvestment Act of 2009. A license amendment application has not been submitted for Phase 2 of the Battle Creek Restoration Project because full funding has not been secured for this phase. Section 16.0 of the MOU provides for its termination in a number of ways, including lack of funding sources. Phase 2 will not be implemented until full funding is secured. At this time, approximately $12 million of the estimated $47 million cost of Phase 2 has been identified but has not been secured.

NMFS recognizes the value of improving spawning access to Battle Creek, as evidenced in its partnership in the MOU. Lindley et al. (2007) states that "restoring flows and habitat…in Battle Creek…[has] the potential to significantly improve the status of affected ESUs, but achieving recovery may require access to additional historically-utilized spawning areas that are currently blocked by dams." In addition, NMFS issued a biological opinion on the OCAP on June 4, 2009. The OCAP biological opinion states the following action to be taken with regard to Battle Creek:

> ***Action I.2.6. Restore Battle Creek for Winter-Run, Spring-Run, and CV Steelhead***
>
> ***Objective:*** *To partially compensate for unavoidable adverse effects of project operations by restoring winter-run and spring-run to the Battle Creek watershed. A second population of winter-run would reduce the risk of extinction of the species from lost resiliency and increased vulnerability to catastrophic events.*
>
> ***Description of Action:*** *Reclamation shall direct discretionary funds to implement the Battle Creek Salmon and Steelhead Restoration Project. Phase 1A funding is currently allocated through various*

> *partners and scheduled to commence in Summer 2009 (Reclamation 2008c). DWR shall direct discretionary funds for Phase 1B and Phase 2, consistent with the proposed amended Delta Fish Agreement by December 31 of each year, Reclamation and DWR will submit a written report to NMFS on the status of the project, including phases completed, funds expended, effectiveness of project actions, additional actions planned (including a schedule for further actions), and additional funds needed. The Battle Creek Salmon and Steelhead Restoration Project shall be completed no later than 2019.*

As stated, the NMFS OCAP biological opinion Action I.2.6 requires Reclamation and DWR to direct discretionary funds to the Battle Creek Restoration Project. However, this statement does not ensure that such discretionary funds will be available, does not provide an alternative funding mechanism in the absence of such funds, as is presently the case, and ultimately does not secure full funding for Phase 2. The biological opinion also does not provide a means for completing the project before 2019.

### 9.3.8.2 Project Support

A number of entities support the Battle Creek Actions, including DWR, the State Water Board, The Nature Conservancy, Metropolitan Water District, Battle Creek Watershed Conservancy, Nor-Cal Fishing Guides and Sportsman Association, the U.S. Department of Agriculture Forest Service, and Lassen National Forest. Entities directly cooperating on the project include DFG, PG&E, Reclamation, USFWS, and NMFS. Local support for the project is high.

### 9.3.8.3 Known Opposition

A landowner abutting one of the construction sites near South Powerhouse and Inskip Diversion Dam on South Fork Battle Creek has filed a lawsuit against DFG and the State Water Board related to their issuance of CEQA documents. The case is pending before the courts.

# 9.4 References

## 9.4.1 Printed References

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NMFS. *See* National Marine Fisheries Service.

U.S. Fish and Wildlife Service. 1984. Evaluation report of the potential impacts of the proposed Lake Red Bluff Water Power Project on the fishery resources of the Sacramento River. Division of Ecological Services. Sacramento, CA.

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USFWS. *See* U.S. Fish and Wildlife Service.

## 9.4.2 Personal Communications

Berry, Mike. Fishery biologist. California Department of Fish and Game, Redding, CA. July 20, 2009—phone conversation with Colleen Lingappaiah, ICF Jones & Stokes, regarding the number of spring-run Chinook salmon and steelhead that could be supported by Phase 2 of the Battle Creek Salmon and Steelhead Restoration Project.

Chapter 10
# Remaining Phases of the HEA

This chapter identifies a preliminary schedule for the remaining phases of the HEA, including:

- continued outreach with the HEA signatories and other stakeholders,
- preparation and approval of a final HEP,
- preparation of a Preliminary Design Report,
- preparation of a Final Design and Permitting Report,
- implementation of approved action(s), and
- preparation of a Final Test Report.

A description of each phase is provided in the following sections. The timing for each phase is also presented in Appendix A.

## 10.1 Outreach

Continuing outreach with the HEA signatories and other stakeholders is a critical component of the HEA process to ensure that implementation of the habitat expansion action(s) approved by NMFS is successful. As described in Chapter 2, the Licensees have coordinated with the HEA signatories since the signing of the HEA. The Licensees have also worked closely with active watershed groups to learn more about potential habitat expansion actions in their watersheds. During the process of selecting the actions recommended in this HEP, the Licensees initiated communication with local stakeholders who hold an interest in the recommended habitat expansion actions.

The Licensees propose to continue working with the signatories and active watershed groups who have been considering the recommended actions for a number of years to further develop details of the actions. To continue outreach with the HEA signatories and other stakeholders, the Licensees anticipate implementing the following actions during the 90-day review period of the draft HEP and throughout production of the final HEP.

- Once the draft HEP has been submitted to NMFS, the Licensees will hold meetings with various stakeholders who may be new to the HEA process and may hold a vested interest in the habitat expansion actions recommended in the draft HEP. These parties may include, but are not limited to:

- landowners/property owners in the vicinity of the Lower Yuba River Habitat Expansion Actions;
- City of Chico, property owners along the affected reach of the Big Chico Creek Habitat Expansion Action;
- Corps, Sacramento District;
- DFG, property owners along the affected reach of the Antelope Creek Habitat Expansion Action; and
- signatories to the Battle Creek Salmon and Steelhead Restoration Project 1999 MOU.

- When the 90-day review period is complete, the Licensees may hold individual meetings with the HEA signatories and other stakeholders to review comments received on the draft HEP.
- The Licensees will continue to coordinate with the following parties to further develop the habitat expansion actions recommended in the draft HEP that may be included in the final HEP:
  - CSU, Research Foundation;
  - DFG;
  - RMT;
  - NMFS;
  - Tehama County RCD; and
  - USFWS, AFRP.
- The Licensees also will meet with the HEA signatories and other stakeholders to keep the parties informed of progress made during production of the final HEP.

The outreach activities listed above will be further developed and modified as needed throughout the remaining phases of the HEA.

# 10.2 Final HEP

As required in Section 4.2 of the HEA, the Licensees (DWR and PG&E) will prepare and submit a final HEP to NMFS within 90 days after the close of the review and comment period on the draft HEP. The Licensees will distribute the final HEP to the HEA signatories and other stakeholders, for their information only.

The following sections describe the steps that will be taken before NMFS will consider approval of the final HEP, including preparation of the final HEP, pre-approval consultation, application of NMFS' Approval Criteria, and a determination of whether the recommended action(s) meet the HET.

## 10.2.1 Contents of the Final HEP

The final HEP will address all comments received during the 90-day review and comment period on the draft HEP. The final HEP will include an explanation of why any comment was not adopted or incorporated into the final plan. The final HEP also will contain all elements required in Section 4.1.3 of the HEA, which include a description of the following:

- the recommended action(s), including any functional start-up testing and future operation and maintenance;
- the rationale for their selection based on the HEA Evaluation Criteria and the Selection Criteria;
- a preliminary schedule for each of the remaining phases associated with the final HEP (described in the following sections), including provisions for anticipated schedule uncertainties;
- the responsibilities of each Licensee for implementing the action(s);
- the estimated contribution of the action(s) to the HET; and
- a pre-feasibility-level cost estimate for implementing the action(s).

## 10.2.2 Pre-Approval Consultation

Before approving the final HEP, NMFS will commence a 60-day consultation process with the HEA signatories, State Water Board, and other stakeholders. During this consultation period, NMFS will consider comments received on the draft HEP and specifically will address comments provided by the HEA signatories or other stakeholders pertaining to whether the habitat expansion actions(s) recommended by the Licensees are already existing requirements and commitments (i.e., actions that are expected to occur in a timeframe comparable to implementation of habitat expansion action(s) under the HEA). Additionally, NMFS will consult with USFWS and DFG to consider the potential benefits and impacts of recommended habitat expansion action(s) on resident fish at the location of the action(s).

## 10.2.3 NMFS Approval Criteria

In determining whether to approve the final HEP, NMFS will review information submitted by the Licensees, comments received from the HEA signatories and other stakeholders, and any other relevant information. NMFS will consider the extent to which the habitat expansion action(s) recommended in the final plan meet the following Approval Criteria:

a. estimated to meet the HET;

b. assures necessary testing, operation, and maintenance;

c. supports establishing a geographically separate, self-sustaining population of spring-run Chinook salmon;

d. supports segregating spring-run Chinook salmon habitat from Central Valley fall-run Chinook salmon;

e. meets the requirements for eligible habitat expansion action(s) pursuant to Section 3 of the HEA (including, but not limited to, dam removals, dam reoperation, creation or enhancement of fishways, water temperature and/or flow improvements, or other physical habitat enhancements); and

f. expected to be implemented within a reasonable period of time.

Pursuant to the HEA, NMFS will not withhold approval for any recommended habitat expansion action(s) determined by NMFS to meet all six Approval Criteria listed above. In addition, NMFS may approve recommended habitat expansion action(s) that meet at least the following four Approval Criteria: (a), (b), (e), and (f).

## 10.2.4 Determination of Contribution to the HET

The actions recommended in this draft HEP (Lower Yuba River Habitat Expansion Actions or the Battle Creek Habitat Expansion Action) meet the HET, as required under the HEA. However, if NMFS does not agree that either habitat expansion action recommended in the final HEP achieves the HET, the Licensees and NMFS may select a neutral third party with appropriate expertise to make an independent estimate of the contribution of recommended actions to the HET. NMFS will take into consideration the independent estimate before making its final decision whether to approve the recommended habitat expansion action.

If NMFS determines that neither habitat expansion action recommended in the final HEP meets the HET, NMFS may consult with the Licensees to consider the acceptability of the either recommended habitat expansion action and, at the discretion of NMFS, either:

- accept one of the recommended habitat expansion actions as meeting the overall goal of the HEA and substantially meeting the HET, within a reasonable margin of estimating error;
- identify other habitat expansion action(s) mutually acceptable to NMFS and the Licensees that may be approved by NMFS, in which case NMFS may approve the final HEP (as modified to incorporate the mutually acceptable habitat expansion action[s]) after consulting with the HEA signatories and other stakeholders; or
- deny approval of the final HEP.

### 10.2.5 Approval Decision by NMFS

After completing its review of the final HEP, NMFS will provide the HEA signatories with a written notice of its approval decision. If NMFS does not approve the final HEP, the written notice will identify the specific reasons why the final plan was not approved. In such case, the Licensees will have an opportunity to assess and amend the deficiencies identified by NMFS and to submit a modified plan for review and approval by NMFS. The Licensees also will distribute the modified plan to the HEA signatories and other stakeholders, for information only. Upon its approval of the modified final HEP, NMFS will provide the HEA signatories with a written notice of its decision.

Within 90 days after the effective date of written notice by NMFS approving the final HEP, the Licensees will distribute to the HEA signatories, other stakeholders, and FERC, for information only:

- the approved HEP reflecting any modifications during the NMFS approval process; and
- an updated schedule for each of the remaining process phases, as identified in Section 4 of the HEA and described in the following sections.

## 10.3 Preliminary Design Phase

For the preliminary design phase of the approved action(s), the Licensees will:

- prepare feasibility-level designs and cost estimates for the approved action(s),
- prepare and distribute semi-annual status reports,
- submit a Preliminary Design Report for approval by NMFS (i.e., a consistency determination), and
- receive new licenses before proceeding.

Each task is described below.

### 10.3.1 Feasibility-Level Designs and Cost Estimates

After the Licensees have distributed an approved HEP, as described above, they will begin the preliminary design phase for the recommended action(s). During the preliminary design phase, the Licensees will prepare feasibility-level designs and cost estimates for the habitat expansion action(s) presented in the approved HEP. If the habitat expansion action(s) involve engineered fishway designs, fishway systems, or major engineered components, the Licensees will consult with the NMFS Southwest Region Fisheries Engineering Team.

## 10.3.2 Semi-Annual Status Reports

During the preliminary design phase, the Licensees will prepare and distribute semi-annual status reports to the HEA signatories and other stakeholders. These reports will be for information only.

## 10.3.3 Preliminary Design Report

The preliminary design phase will include the Licensees' preparation of a Preliminary Design Report, which will consist of:

- a preliminary design of the approved habitat expansion action(s);
- updated cost estimates; and
- a schedule for each of the remaining process phases, as identified in Section 4 of the HEA and described in the following sections.

## 10.3.4 Consistency Determination by NMFS

After completing the Preliminary Design Report, the Licensees will submit the report to NMFS for its determination of whether the report is materially consistent with the approved HEP. The Licensees also will distribute the Preliminary Design Report to the HEA signatories and other stakeholders, for information only.

After receiving the Preliminary Design Report, NMFS will have 90 days to provide the HEA signatories with a written notice of its consistency determination. The 90-day review period may be extended for good cause or if NMFS solicits additional information from the Licensees that is necessary and appropriate for NMFS to determine whether the Preliminary Design Report is materially consistent with the approved HEP.

After receiving any additional information necessary and appropriate for issuance of a determination, NMFS will have 90 days to provide the HEA signatories with a written notice of its consistency determination. If NMFS determines that the Preliminary Design Report is not materially consistent with the approved HEP, the written notice will identify the specific elements of the Preliminary Design Report that are not materially consistent. In this event, the Licensees will have an opportunity to assess and amend the inconsistencies identified by NMFS and to prepare a modified Preliminary Design Report, which will be submitted to NMFS for a consistency determination.

### 10.3.5 FERC Licensing

Before proceeding with the final design and permitting phase and other process phases, as identified in Section 4 of the HEA and described in the following sections, the Licensees must receive, and find acceptable, new project licenses from FERC for the Oroville, Poe, and Upper North Fork Feather River Projects.

## 10.4 Final Design and Permitting Phase

For the final design and permitting phase of the approved action(s), the Licensees will:

- prepare bid-level design and cost estimates;
- apply for all permits, approvals, and rights necessary to implement;
- prepare and distribute semi-annual status reports; and
- submit a Final Design and Permitting Report for NMFS approval (consistency determination).

Each task is described below. If permitting and design for the recommended action is already complete, the Licensees will use the completed documentation rather than begin a new permitting and design phase.

### 10.4.1 Bid-Level Designs, Cost Estimates, and Related Permitting

Following a determination of consistency by NMFS of the Preliminary Design Report, and following the Licensees' acceptance of each of the new licenses from FERC for the Oroville, Poe, and Upper North Fork Feather River Projects, the Licensees will begin the final design and permitting phase. During this phase, the Licensees will prepare bid-level designs and cost estimates and will apply for all permits, approvals, and rights necessary to implement the approved HEP. If the approved habitat expansion action(s) involve engineered fishway designs, fishway systems, or major engineered components, the Licensees will consult with the NMFS Southwest Region Fisheries Engineering Team.

### 10.4.2 Semi-Annual Status Reports

During the final design and permitting phase, the Licensees will prepare and distribute semi-annual status reports to the HEA signatories and other stakeholders. The semi-annual status reports will be for information only.

### 10.4.3 Final Design and Permitting Report

The final design and permitting phase will include the Licensees preparing a Final Design and Permitting Report, which will consist of:

- final designs and permit status of the approved habitat expansion action(s);
- updated cost estimates; and
- a schedule for each of the remaining process phases, as identified in Section 4 of the HEA and described in the following sections.

### 10.4.4 Consistency Determination by NMFS

After completing the Final Design and Permitting Report, the Licensees will submit the Final Design and Permitting Report to NMFS for a determination of whether the Final Design and Permitting Report is materially consistent with the approved HEP. The Licensees also will distribute the Final Design and Permitting Report to the HEA signatories and other stakeholders, for information only.

After receiving the Final Design and Permitting Report, NMFS will have 90 days to provide the HEA signatories with a written notice of its consistency determination. The 90-day review period may be extended for good cause or if NMFS solicits additional information from the Licensees that is necessary and appropriate for NMFS to determine whether the Final Design and Permitting Report is materially consistent with the approved HEP.

After receiving any additional information necessary and appropriate for issuance of a determination, NMFS will have 90 days to provide the HEA signatories with a written notice of its consistency determination. If NMFS determines that the Final Design and Permitting Report is not materially consistent with the approved HEP, the written notice will identify the specific elements of the Final Design and Permitting Report that are not materially consistent. In this event, the Licensees will have an opportunity to assess and amend the inconsistencies identified by NMFS and to prepare a modified Final Design and Permitting Report, which will be submitted to NMFS for a consistency determination.

## 10.5 Implementation Phase

For the implementation phase of the approved action(s), the Licensees will:

- implement the proposed action(s) individually, jointly, or through cooperative efforts with others;
- prepare and distribute semi-annual status reports; and
- prepare and distribute a Final Report.

Each task is described below.

### 10.5.1 Implementation of Approved Action(s)

Following the consistency determination of the Final Design and Permitting Report, the Licensees will implement the approved HEP. If any final permit, approval, or right applied for during the final design and permitting phase contains a condition that is materially inconsistent with the approved HEP, the Licensees will resolve the inconsistency in a way that is acceptable to NMFS, after notifying and consulting with the HEA signatories and other stakeholders.

Implementing the approved action(s) by the Licensees may occur individually, jointly, or through cooperative efforts with others. Implementation of the approved action, and any subsequent operation and maintenance actions, will not extend beyond the term described in Section 1.4 of the HEA (i.e., through the term of the last expiring new project license received from FERC).

### 10.5.2 Semi-Annual Status Reports

The Licensees will prepare and distribute semi-annual status reports to the HEA signatories and other stakeholders. The semi-annual status reports will be for information only.

### 10.5.3 Final Report

Once implementation of the approved action(s) is complete, the Licensees will distribute to the HEA signatories and other stakeholders, for information only, a Final Report with updated cost and schedule information for each of the remaining phases, as identified in Section 4 of the HEA and described in the following sections. The Final Report will also include:

- the proposed start time for each action,
- expected time to complete,
- expected time to realize environmental benefits, and
- expected time to realize ecological benefits.

## 10.6 Final Test Phase

For the final test phase of the approved action(s), the Licensees will:

- perform functional start-up testing,
- prepare and distribute semi-annual status reports, and

- submit a Final Test Report for approval by NMFS (consistency and functionality determination).

Each task is described below.

## 10.6.1 Start-Up Testing

Upon completing implementation of the approved habitat expansion action(s) as described in the approved HEP, the Licensees will perform functional start-up testing to technically validate the specified designs for the action(s), as may be required by the approved HEP and as may be further described in or modified by the Final Design and Permitting Report.

## 10.6.2 Semi-Annual Status Reports

During the final test phase, the Licensees will prepare and distribute, as necessary, semi-annual status reports to the HEA signatories and other stakeholders. The semi-annual status reports will be for information only.

## 10.6.3 Final Test Report

This final test phase will include the Licensees' preparation of a Final Test Report, which will contain the design and function of the actions implemented and the test results and conclusions from any start-up testing that may be required.

## 10.6.4 Functionality Determination by NMFS

After completing the Final Test Report described above, the Licensees will submit the Final Test Report to NMFS for a functionality determination. NMFS will determine: (1) whether any functional start-up testing required by the approved HEP, as may be further described in or modified by the Final Design and Permitting Report, has been performed; and (2) whether such testing demonstrates that all element(s) of the habitat expansion action(s) relevant to the functional start-up testing are functional. The Licensees also will distribute the Final Test Report to the HEA signatories and other stakeholders, for information only.

After receiving the Final Test Report, NMFS will have 90 days to provide the HEA signatories with a written notice of its functionality determination. The 90-day review period may be extended for good cause or if NMFS solicits additional information from the Licensees that is necessary and appropriate for NMFS to

determine whether all element(s) of the habitat expansion action(s) relevant to the functional start-up testing are functional.

After receiving any additional information necessary for issuance of a determination, NMFS will have 90 days to provide the HEA signatories with a written notice of its functionality determination. If NMFS concludes that any element(s) of the habitat expansion action(s) relevant to the functional start-up testing are not functional, the written notice will specifically identify such non-functional element(s). In this event, the Licensees will have an opportunity to assess all elements associated with the habitat expansion action(s); complete any repairs or replacement, as necessary; and prepare a modified Final Test Report, which will be submitted to NMFS for a functionality determination.

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Appendix A

# Approval and Implementation Schedule for Habitat Expansion Actions

## Approval and Implementation Schedule for Habitat Expansion Actions

| HEA Section Reference | Description | November 20, 2009 | February 20, 2010 | May 20, 2010 | September 2010 | December 2010 | March 2011 | June 2011 | December 2011 | March 2012 | March 2013 | ? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4.1 | Licensees submit draft Habitat Expansion Plan | | | | | | | | | | | |
| 4.1.3 | Parties and others review and comment on draft Habitat Expansion Plan | | <90 days | | | | | | | | | |
| 4.2 | Licensees prepare and submit final Habitat Expansion Plan | | | <90 days | | | | | | | | |
| 4.2.7 | NMFS reviews and approves final Habitat Expansion Plan, which includes consultation with Parties and others | | | | variable (~90 days) | | | | | | | |
| 4.2.8 | Licensees distribute NMFS-approved final Habitat Expansion Plan | | | | | <90 days | | | | | | |
| 4.3 | Licensees prepare Preliminary Design Report | | | | | | variable (~90 days) | | | | | |
| 4.4 | NMFS determines Consistency of Preliminary Design Report | | | | | | | <90 days | | | | |
| 4.5 | Licensees prepare Final Design and Permitting Report (after issuance of New Project Licenses) | | | | | | | | variable (~180 days) | | | |
| 4.6 | NMFS determines Consistency of Final Design and Permitting Report | | | | | | | | | <90 days | | |
| 11.1 | Licensees' last opportunity to withdraw from HEA | | | | | | | | | | 12 months | |
| 4.7 | Licensees implement actions | | | | | | | | | | | variable |
| 4.8 | Licensees prepare Final Test Report | | | | | | | | | | | variable |
| 4.9 | NMFS determines functionality | | | | | | | | | | | <90 days |

Notes:

| | |
|---|---|
| HEA | Habitat Expansion Agreement |
| Licensees | California Department of Water Resources and Pacific Gas and Electric Company |
| NMFS | National Marine Fisheries Service |
| Parties | Signatories to the HEA |

Appendix B

# Working Definitions of Evaluation, Selection, and Approval Criteria

Habitat Expansion Agreement

# Working Definitions of Evaluation, Selection, and Approval Criteria

This document provides working definitions of the Evaluation, Selection, and Approval Criteria found in the Habitat Expansion Agreement (HEA). These definitions were developed by the Steering Committee to aid in the process of selecting actions for inclusion in the Habitat Expansion Plan (HEP). The working definitions are meant to complement the HEA definitions and assist in their communication; they are not meant to replace the definitions presented in the HEA.

## HEA Evaluation Criteria

This section presents working definitions for the 17 Evaluation Criteria (items a–q contained in Section 4.1.1 of the HEA). These definitions form the basis for the Steering Committee's application of the Evaluation Criteria to the List of Potential Actions. Section 4.1.1 states: "The Licensees shall use the following non-exclusive and non-prioritized Evaluation Criteria to screen potential habitat expansion action(s) and develop a preliminary list of viable actions."

*(a) favorable feasibility (technically feasible; supported by accepted science; low potential for disease and other risks; proven actions are favored over experimental actions);*

Actions/projects should have a high likelihood of success. The type of action should be technically feasible, with a proven track record of results in similar settings. There should be a high degree of scientific support both in terms of the feasibility of the action and its potential contribution to the Habitat Expansion Threshold (HET).

*(b) adequate scale of expansion of spawning, rearing and adult holding habitat (one or more larger contiguous gains is favored over numerous smaller gains; increased habitat is favored over enhanced habitat);*

The HEP should focus sufficient effort to make measurable and meaningful improvement in habitat for spring-run Chinook salmon. This requires that projects be designed to solve problems limiting existing habitat potential. Several small, independent projects may not actually solve current problems and hence would provide less benefit than a larger, potentially integrated project that focuses on critical limiting factors. Similarly, the greatest potential for the HEP to make meaningful change may involve focusing projects on a limited number of watersheds (sub-basins of the Sacramento River Basin) rather than spreading out projects across many watersheds.

*(c) favorable sustainability of action;*

The intent of the HEA is to create "permanent" solutions to problems, or at least to provide benefits through the term of a typical Federal Energy Regulatory Commission license (i.e., up to 50 years). Where possible, projects should address the root cause of current habitat constraints rather than dealing with their symptoms or surface expression and should consider the potential effects of climate change. Once implemented, projects ideally would be self-sustaining (i.e., requiring a minimum amount of maintenance over the long term). In conjunction with Evaluation Criterion (e), projects providing volitional access for fish to currently unoccupied habitat would likely be considered more sustainable than passage projects requiring high levels of human intervention.

*(d) favorable cost-effectiveness and economic feasibility (including consideration of costs necessary to operate and maintain the expansion);*

Project funding under the HEA will include capital cost, operations and maintenance (O&M), and project administration. Projects that show efficient use of funds for these cost elements will be favored. One measure of cost effectiveness is the estimated net increase in the population of spawning fish (i.e., the contribution toward the HET) versus the total cost of the action. Projects that include cost sharing, labor sharing, or other measures that allow the HEP to leverage funds, while making meaningful change, would also be favored.

*(e) minimal human intervention needed to achieve access to expanded spawning, rearing and adult holding habitat (volitional access is favored over that which requires a high degree of human intervention);*

Projects that provide access into habitat currently blocked to anadromous passage will be evaluated relative to the amount of human intervention (e.g., annual maintenance) required. For example, a project that removes a barrier to allow free access (requiring no further maintenance) would be favored over a trap-and-haul project that requires collection and transport of fish.

*(f) favorable spatial separation from other populations or runs to maintain genetic diversity by minimizing interbreeding;*

A priority within the HEA is the segregation of habitat for spring-run and fall-run Chinook salmon (see Section 4.2.3[d]). In the Central Valley, introgression of fall- and spring-run Chinook salmon has been identified as a potential factor limiting spring-run Chinook. In many cases, this is due to the spawning of hatchery-produced fall-run Chinook in areas where spawning of spring-run Chinook occurs. To address this problem, projects that encourage the separation of fall- and spring-run Chinook will be considered favorable under this criterion. Separation may be achieved either through physical barriers or through the development of habitat conditions that favor spring-run fish over fall-run fish. For example, projects that provide or enhance habitat for spawning in upper portions of a watershed favored by spring Chinook would be more desirable than projects enhancing spawning conditions in lower reaches favored by fall Chinook. Seasonal flow releases also can be used to enhance passage and spawning of spring-run Chinook salmon.

*(g) favorable spatial separation from other spawning streams to minimize population impacts of a stream-specific adverse event (geographic distribution is favored over centralization);*

A priority within the HEA is the development of a new, geographically separate, self-sustaining population of spring-run Chinook (see Section 4.2.3[c]). NMFS has identified presently viable spring Chinook populations in Mill, Deer, and Butte Creeks—a part of the Northern Sierra Nevada diversity group delineated by the Central Valley Technical Recovery Team (Lindley et al. 2007). NMFS recovery efforts call for development of additional viable spring-run populations. In conjunction with Evaluation Criterion (b), a number of projects might need to be concentrated in a single watershed to result in sufficient environmental change to support an additional population.

*(h) acceptable length of time to implement (earlier gains are favored over later gains);*

Sacramento River spring-run Chinook salmon are in need of immediate assistance to support their recovery. Thus, factors important to the success of a project include not only the length of time to implement the project but also the length of time to realize benefits. Thus, "shovel-ready" projects (i.e., those projects for which implementation can begin within approximately 5 years) will be favored. "Implementation" means initiation of construction after approval of the final HEP.

The more favorable projects will be those that need minimal additional public process, particularly related to permitting, zoning, or land use issues. In addition, projects that benefit spring-run Chinook within a relatively short period of time (e.g., approximately 10 years or less) will be favored. The environmental and biological benefits of many habitat restoration actions occur only after extended periods. For example, sufficient recovery of riparian forests to address temperature, water quality, and channel needs may require timeframes from decades to centuries to realize. While such projects will not be excluded from consideration, projects that can be implemented sooner and realize benefits within a relatively short period will be preferred.

*(i) favorable local/political support;*

To provide benefits in the desirable time frame (Evaluation Criterion [h]) and to make best use of available funds (Evaluation Criterion [d]), it is important that HEP projects have public support. Primary stakeholders include affected land owners, management agencies, Resource Conservation Districts (RCDs), and watershed conservancies. As a project moves through the environmental permitting/design process, crucial support from the stakeholders will be sought. An extended public review process is outside the purview of the HEA. Proposed projects should be vetted with watershed councils; RCDs; and other local, state, and federal agencies. To the maximum extent possible, permitting concerns, land ownership, and required access should be identified in the evaluation of potential actions.

*(j) consistency with NMFS Viable Salmonid Population guidance, ESA recovery goals and recovery plan (as available), and expected contribution to species recovery (higher consistency and greater contributions are favored);*

The NMFS Viable Salmonid Population (VSP) concept provides direction for characterization of salmonid populations listed under the Endangered Species Act (ESA) (McElhany et al. 2000). The VSP concept underlies most NMFS ESA recovery planning. Elements of VSP thinking are woven throughout the HEA (e.g., Evaluation Criteria [f] and [g]). VSP is also incorporated as part of the HEA conceptual framework. However, VSP does not provide specific criteria for recovery; these are left to recovery

planners (e.g., Lindley et al. 2004). Based on VSP and its application to salmon recovery, projects should contribute to the following: (1) abundance, through contribution to the HET; (2) productivity, by increasing the quality of existing and new habitat for spring-run Chinook; (3) biological diversity, by enhancing the breadth of habitat and by discouraging interbreeding of fall- and spring-run Chinook (Evaluation Criterion [f]); and (4) spatial diversity, by promoting development of an additional viable spring-run Chinook population(s) in the Sacramento River Basin (Evaluation Criterion [g]).

*(k) balance of benefits to Spring-Run and Steelhead (actions that provide a balance of benefits to both Spring-Run and Steelhead are favored over actions that primarily benefit one species; if multiple actions are undertaken, a combination of actions that provides a balance of benefits to both Spring-run and Steelhead is favored);*

The HET provides a numeric habitat goal for spring-run Chinook salmon as the priority species of the HEA and states that "expansion of habitat for spring-run typically accommodates steelhead as well" (see Section 2.2). Spring-run Chinook and steelhead populations often overlap and are found in similar habitats within the same watersheds. Hence, expansion of habitat to meet the HET numeric threshold for spring-run Chinook should also benefit steelhead. While habitat requirements for spring-run Chinook and steelhead are similar, they are not identical. For example, the two species are separated by adult return timing and juvenile and adult life history. However, projects that meet the common habitat requirements of spring-run Chinook and steelhead and contribute to the restoration of both species will be favored.

*(l) consistency with other resource uses such as water supply, public safety, flood control, recreation, and power production;*

Projects should identify potential conflicts with other uses of the affected watershed and seek to avoid or minimize adverse impacts to other resource uses. In conjunction with Evaluation Criterion (i), if a potential project is likely to impact other resource uses, there should be demonstrated support for the project from the affected stakeholders (e.g., written documentation of the landowner/water right holder's agreement). Those projects that are most consistent with other resource uses and/or have support from affected stakeholders will be favored.

*(m) favorable relative availability of appropriate stocks of Spring-Run and Steelhead for reintroduction;*

The purpose of the HEP is to provide habitat for spring-run Chinook salmon and steelhead, with the expectation that fish will expand into new or enhanced habitat. This process of movement of individuals into expanded or enhanced habitat occurs when adult fish stray from their natal areas and spawn in non-natal habitat. Colonization of habitat provided under the HEP will be enhanced in watersheds with some existing remnant populations. Colonization of those watersheds with no spring-run Chinook and/or steelhead, or with no known historical occurrence of these species, would likely be slower without direct intervention (i.e., supplementation from nearby streams with naturally reproducing populations and/or hatcheries). Consequently, projects on streams with remnant populations or with nearby naturally reproducing populations will be favored over those requiring hatchery supplementation.

*(n) low expectation for the action to be undertaken by the Licensees or others in the near future;*

Projects required as part of other regulatory or legal proceedings are not eligible, as described in Section 3.2 of the HEA. If a project is not likely to be implemented by others within a reasonable period

of time (e.g., approximately 5 years), it may be considered. Refer to discussion of Evaluation Criterion (h).

*(o) favorable potential to benefit other anadromous, catadromous, and resident fisheries affected by the Feather River Hydroelectric Projects;*

Enhancement and expansion of habitat favors a community of co-evolved fish, invertebrate, and plant species. Projects that will provide identifiable benefits to other native fish species, including lamprey, sturgeon, resident trout, hardhead, Sacramento sucker, and pikeminnow, among others will be favored.

*(p) low expectation for adverse impact on listed species and destruction or adverse modification of critical habitat under the ESA (actions with low or no impact are favored); and*

The HEA is intended to benefit listed spring-run Chinook salmon and steelhead. Projects should avoid or minimize adverse impacts to other ESA-listed fish, wildlife, amphibian, and plant species.

*(q) low potential for an adverse impact on historic or cultural resources.*

Projects should avoid or minimize adverse impacts to known historic and pre-historic cultural resources.

# HEA Selection Criteria

This section presents working definitions for the four Selection Criteria (items a–d contained in Section 4.1.2 of the HEA). These definitions form the basis for the Steering Committee's application of the Selection Criteria to the list of Viable Actions. Section 4.1.2 states "After developing a preliminary list of viable habitat expansion action(s) using the Evaluation Criteria set forth in Section 4.1.1 above, the Licensees shall use the following non-prioritized Selection Criteria to select recommended habitat expansion action(s) for implementation:"

*(a) contribution to achieving the Habitat Expansion Threshold;*

Section 2.2 of the HEA identifies the specific goal "to expand spawning, rearing and adult holding habitat sufficiently to accommodate an estimated net increase of 2,000 to 3,000 Spring-run for spawning ('Habitat Expansion Threshold') in the Sacramento River Basin…". Projects may contribute to expanding one or more of these three functional types of habitat, with the final result being achievement of the HET.

Projects are expected to increase the habitat potential for steelhead as well. The contribution of projects to the HET will be defined by the estimated change in equilibrium abundance of spring-run Chinook in the Sacramento River Basin that results from expanding the quantity and quality of habitat available to spring-run Chinook and steelhead. The expansion of habitat potential will be structured to support the development of an additional viable population of spring-run Chinook in the Sacramento River Basin, support the separation of fall and spring runs of Chinook salmon, and be consistent with the Evaluation Criteria in Section 4.1.1.

*(b) most cost-effective compared to other potential habitat expansion actions;*

For each Viable Action, a rough estimate of its cost and contribution to the HET will be determined. Each Viable Action then will be ranked in terms of its cost effectiveness (i.e., the cost of the action versus its contribution to the HET). Refer to the discussion of favorable cost effectiveness in Evaluation Criterion (d).

*(c) feasibility (action[s] can reasonably be accomplished);*

As stated in Evaluation Criterion (a), actions/projects must have a high likelihood of success (i.e., they must be highly feasible). The term "feasibility" is being interpreted broadly to include the concepts described for four Evaluation Criteria: (a) technical feasibility, (d) economic feasibility, (i) favorable political and local support, and (l) consistency with other resource uses.

*(d) timing (action[s] can be accomplished in a reasonable period of time).*

As noted in Evaluation Criterion (h), factors important to the success of a project include not only the length of time to implement the project but also the length of time to realize benefits. Thus, the HEP will favor "shovel-ready" projects that can be implemented in a reasonable period of time (e.g., less than approximately 5 years). The more favorable projects will be those that need minimal additional public process, particularly related to permitting, zoning, or land use issues. In addition, projects that benefit spring-run Chinook within a relatively short period of time (e.g., approximately 10 years or less) will be favored.

# NMFS Approval Criteria

This section presents working definitions for the six NMFS Approval Criteria (items a–f contained in Section 4.2.3 of the HEA). These definitions are being considered as part of the Steering Committee's selection process. Section 4.2.3 states: "In determining whether to approve the Final Habitat Expansion Plan, NMFS shall review information submitted by the Licensees, comments by other Parties and directly affected and responsive third parties, and any other relevant information, and consider the extent to which the habitat expansion action(s) recommended in the Plan meet the following Approval Criteria."

*(a) estimated to meet the Habitat Expansion Threshold;*

As stated in Selection Criterion (a), the proposed projects must expand habitat to support 2,000 to 3,000 spring-run Chinook salmon. It is assumed that the Steering Committee and NMFS will agree on a readily available quantification method to define the contribution of the proposed projects to the HET. Refer to Selection Criterion (a) for further discussion on the HET.

*(b) assures necessary testing, operation, and maintenance;*

Each proposed project must include a funding mechanism for a period of time equivalent to the life of a typical FERC license (i.e., up to 50 years). The HEP will describe any proposed O&M and other necessary actions, as well as the associated funding mechanism, for a period of 50 years. PG&E and DWR will comply with the requirements of the HEA concerning reporting to the signatories (identified in Section 6.2).

*(c) supports establishing a geographically separate, self-sustaining population of Spring-Run;*

As discussed in Evaluation Criterion (g), the proposed projects should support development of a viable population of spring-run Chinook salmon within the Sacramento River Basin, in addition to those that already exist in Mill, Deer, and Butte Creeks. The proposed actions need to provide habitat that is of sufficient quantity (e.g., watershed size of 500 $km^2$ or greater as a guideline) and quality, and sufficiently separate to support a self-sustaining population of spring-run Chinook.

*(d) supports segregating Spring-Run habitat from Central Valley fall-run Chinook salmon;*

As discussed in Evaluation Criterion (f), the proposed projects should support segregation of spring-run and fall-run Chinook salmon populations. Segregating the two runs can involve creating a segregation barrier, increasing instream flow, or enhancing habitat for spring-run over fall-run Chinook.

*(e) meets the requirements for eligible habitat expansion action(s) pursuant to Section 3 of this Agreement;*

As indicated in Section 3 of the HEA: (1) a variety of action types can fulfill the HEA (e.g., dam removal, dam re-operation, creation or enhancement of fishways, and water temperature/flow improvement); (2) the proposed actions must ensure future O&M and include functional start-up testing as needed; and (3) actions identified in other venues are eligible for consideration provided that what is implemented under the HEA results in an expansion of habitat over any existing requirements and commitments. As stated in Evaluation Criterion (n), projects required as part of other proceedings or with a high likelihood of being implemented within approximately 5 years will not be favored and may be considered ineligible.

*(f) expected to be implemented within a reasonable period of time.*

Refer to discussion of Evaluation Criterion (h).

# References

Lindley, S. T. and others. 2004. Population structure of threatened and endangered Chinook salmon ESUs in California's Central Valley Basin. National Oceanic and Atmospheric Administration, National Marine Fisheries Service. (NOAA Technical Memorandum NOAA-TM-NMFS-SWFSC-360.) 56 pages.

Lindley, S. T. and others. 2007. Framework for assessing viability of threatened and endangered Chinook salmon and steelhead in the Sacramento-San Joaquin Basin. San Francisco Estuary and Watershed Science [online serial] Volume 5, Issue 1, Article 4.

McElhany, P., M. H. Ruckelshaus, M. J. Ford, T. C. Wainwright, and E.P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionary significant units. U.S. Department of Commerce. (NOAA Technical Memorandum NMFS-NWFSC-42.) 156 pages.

Appendix C

# Habitat Expansion Actions

Appendix C1

# Draft Working List of Potential Actions

## Working List of Potential Habitat Expansion Actions

The following non-prioritized list of actions has been compiled by the HEA Steering Committee based on the potential of the actions to help satisfy requirements of the Habitat Expansion Agreement. The working list is pre-decisional and does not necessarily represent actions that will be selected by the HEA Steering Committee to include in the Draft Habitat Expansion Plan.

| Reference Number | Description of Action | Target Life Stage(s) | Stream | Source Document | Reference Cited in Source | Notes |
|---|---|---|---|---|---|---|
| **Northern Sierra Nevada Spring Run Salmon Diversity Group** | | | | | | |
| NS-1 | Supplement flows in Antelope Creek with water acquired from willing sellers consistent with applicable guidelines or negotiate agreements to allow passage of juvenile and adult spring-, fall- and late-fall-run Chinook salmon and steelhead. | All | Antelope Creek | PG&E/CalTrout Prioritized Actions List | AFRP Restoration Plan (USFWS 2001). | Economic feasibility and level of local/political support for flow supplementation are unknown. Additionally, the benefit of flow supplementation to maintenance of spatial separation is unclear. |
| NS-2 | Enhance watershed resiliency by identifying and implementing projects that would reduce the potential for, and magnitude of a catastrophic wildfire, restore meadows to potentially increase summer flows and reduce local water temperatures, or increase riparian shade and reduce sources of chronic road-related erosion of sediment (U.S. Forest Service Long-Term Anadromous Fish Conservation Strategy). | All | Antelope Creek | NMFS Recovery Plan Co-Manager Review Draft | U.S. Forest Service Long-term Anadromous Fish Conservation Strategy. | |
| NS-3 | Implement the Edwards Dam Ladder construction project (AFRP website 2005).<br><br>Conduct fish passage evaluation at all agricultural diversions to determine if they meet NMFS' fish passage criteria. Design and install state-of-the-art fish passage facilities at diversions that currently do not meet the passage criteria. | Adult Immigration | Antelope Creek | NMFS Recovery Plan Co-Manager Review Draft | http://www.delta.dfg.ca.gov/afrp/ | The Edwards Dam Ladder construction project was completed in October 2007. Juvenile bypass facilities are still needed as of October 2008. |
| NS-4 | Develop an Antelope Creek fish passage assessment, including recommendations for improving channel connectivity, flow consolidation, and minimizing entrainment through installation of state-of-the-art fish passage facilities at diversions (AFRP Website 2005). | Adult Immigration | Antelope Creek | NMFS Recovery Plan Co-Manager Review Draft | http://www.delta.dfg.ca.gov/afrp/ | |

| Reference Number | Description of Action | Target Life Stage(s) | Stream | Source Document | Reference Cited in Source | Notes |
|---|---|---|---|---|---|---|
| NS-5 | Evaluate and dedicate instream flows and consolidate channels to facilitate upstream attraction and passage (NMFS 2007b).<br><br>Dedicate instream flows through water exchange agreements with all water users.<br><br>Improve passage conditions at Paynes crossing to allow upstream passage during low flows. | Adult Immigration, Adult Holding | Antelope Creek | NMFS Recovery Plan Co-Manager Review Draft | Summary of Threats and Recovery Actions for Spring-Run and Winter-Run Chinook Salmon. (Notes from the Sacramento Salmon and Steelhead Recovery Workshop, May 22, 2007.) | Also referred to as Tehama Wildlife Area crossing. AFRP is currently funding a fish passage feasibility study at this site, but as of October 2008 funding has not been identified for construction. |
| NS-6 | Identify gravel starved areas in Antelope Creek and implement gravel additions. | Spawning | Antelope Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | |
| NS-7 | Build sediment retention structures; fortify streambanks with native vegetation. | Spawning, Egg Incubation | Antelope Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | |
| NS-8 | Implement bank revetment removal programs and projects and breach or remove abandoned levees during set-back levee projects. | Summer/Winter Rearing, Juvenile Emigration | Antelope Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | |
| NS-9 | Implement projects to increase floodplain habitat availability to improve habitat conditions for juvenile rearing (NMFS 2007b). | Summer/Winter Rearing | Antelope Creek | NMFS Recovery Plan Co-Manager Review Draft | Summary of Threats and Recovery Actions for Spring-Run and Winter-Run Chinook Salmon. (Notes from the Sacramento Salmon and Steelhead Recovery Workshop, May 22, 2007.) | |
| NS-10 | Implement projects that cooperatively work with landowners to modify existing diversions so that fish do not become entrained in agricultural fields. | Juvenile Emigration | Antelope Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | |
| NS-11 | Screen diversions in Antelope Creek | Juvenile Emigration | Antelope Creek | PG&E/CalTrout Prioritized Actions List | Collaborative Group 2006. | |
| NS-12 | Remove the partial barrier (old agricultural dam) approximately 0.4 river miles downstream of Higgins Hole, located on private property. | Adult Immigration | Big Chico Creek | HEA Steering Committee | No reference cited. | Fish passage evaluation has not been done for this site. |

| Reference Number | Description of Action | Target Life Stage(s) | Stream | Source Document | Reference Cited in Source | Notes |
|---|---|---|---|---|---|---|
| NS-13 | Implement the Iron Canyon Fish Passage Project (AFRP Website 2005). Conduct Fish Passage evaluation at all dams and diversions to determine if they meet NMFS fish passage criteria. Design and install state-of-the-art fish passage facilities at diversions (1-mile dam, 5-mile dam) that currently do not meet the passage criteria. | Adult Immigration | Big Chico Creek | NMFS Recovery Plan Co-Manager Review Draft | http://www.delta.dfg.ca.gov/afrp/ | |
| NS-14 | Repair the Iron Canyon fish ladder in Big Chico Creek. | Adult Immigration | Big Chico Creek | PG&E/CalTrout Prioritized Actions List | AFRP Restoration Plan (USFWS 2001). | |
| NS-15 | Repair the Lindo Channel weir and fishway at the Lindo Channel box culvert at the Five-Mile Diversion in Big Chico Creek. | Adult Immigration | Big Chico Creek | PG&E/CalTrout Prioritized Actions List | AFRP Restoration Plan (USFWS 2001). | Need to acquire more information about the box culvert and fishway mentioned in this action. |
| NS-16 | Protect spring-run Chinook salmon summer holding pools in Big Chico Creek by obtaining from willing sellers titles or conservation easements on lands adjacent to the pools. | Adult Holding | Big Chico Creek | PG&E/CalTrout Prioritized Actions List | AFRP Restoration Plan (USFWS 2001). | Benefit of this action would depend on the implementation of the Iron Canyon Fish Ladder project. Cost would be dependent on the landowners' willingness to sell. |
| NS-17 | Enhance watershed resiliency by identifying and implementing projects that would reduce the potential for, and magnitude of a catastrophic wildfire, restore meadows to potentially increase summer flows and reduce local water temperatures, or increase riparian shade and reduce sources of chronic road-related erosion of sediment. | All | Big Chico Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | |
| NS-18 | Develop a spawning gravel budget and implement an augmentation plan and use flow management to optimize spawning weighted usable area in consideration of hydrologic limitations and other species (e.g., steelhead) and life stage requirements. Implement One-mile Dam modification and gravel supplementation project (City of Chico); add spawning gravels at Five-Mile Diversion (AFRP Website 2005). | Spawning | Big Chico Creek | NMFS Recovery Plan Co-Manager Review Draft | http://www.delta.dfg.ca.gov/afrp/ | |
| NS-19 | Identify stream reaches that have been most altered by anthropogenic factors and reconstruct a natural channel geometry scaled to current channel forming flows. | All | Big Chico Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | |

| Reference Number | Description of Action | Target Life Stage(s) | Stream | Source Document | Reference Cited in Source | Notes |
|---|---|---|---|---|---|---|
| NS-20 | Eliminate sources of chronic sediment delivery from roads and other near stream development by out-sloping roads, constructing diversion prevention dips, replacing under-sized culverts and applying other storm proofing guidelines. | Egg Incubation | Big Chico Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | |
| NS-21 | Implement projects to increase floodplain habitat availability to improve habitat conditions for juvenile rearing (NMFS 2007b). | Summer/Winter Rearing | Big Chico Creek | NMFS Recovery Plan Co-Manager Review Draft | Summary of Threats and Recovery Actions for Spring-Run and Winter-Run Chinook Salmon. (Notes from the Sacramento Salmon and Steelhead Recovery Workshop, May 22, 2007.) | |
| NS-22 | Cooperate with local landowners to encourage revegetation of denuded stream reaches; and establish, restore, and maintain riparian habitat on Big Chico Creek. | Juvenile Emigration, Summer/Winter Rearing | Big Chico Creek | PG&E/CalTrout Prioritized Actions List | AFRP Restoration Plan (USFWS 2001) | |
| NS-23 | Purchase existing water rights from willing sellers. | All | Butte Creek | PG&E/CalTrout Prioritized Actions List | AFRP Restoration Plan (USFWS 2001). | All Lower Butte Creek actions need to be investigated to determine if the actions were carried out in previous restoration activities. |
| NS-24 | Enhance watershed resiliency by identifying and implementing projects that would reduce the potential for, and magnitude of a catastrophic wildfire, restore meadows to potentially increase summer flows and reduce local water temperatures, or increase riparian shade (U.S. Forest Service Long-term Anadromous Fish Conservation Strategy). | All | Butte Creek | NMFS Recovery Plan Co-Manager Review Draft | U.S. Forest Service Long-term Anadromous Fish Conservation Strategy. | |
| NS-25 | Maintain state-of-the-art fish passage facilities at diversions to meet NMFS' passage criteria.<br><br>Study feasibility of consolidating diversion points to minimize the number of diversions on Butte Creek. Based on this study, consolidate diversions where feasible. | Adult Immigration | Butte Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | Some consolidation of diversions has already been done for the lower portion of Butte Creek as of Oct 2008; uncertain if other diversions could also be consolidated. |
| NS-26 | Identify gravel starved areas in Butte Creek and implement gravel additions. Develop a spawning gravel budget and implement an augmentation plan and use flow management to optimize spawning weighted usable area in consideration of hydrologic limitations and other species (e.g., steelhead) and life stage requirements. | Spawning | Butte Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | |

| Reference Number | Description of Action | Target Life Stage(s) | Stream | Source Document | Reference Cited in Source | Notes |
|---|---|---|---|---|---|---|
| NS-27 | Install and maintain real-time flow monitoring gages.<br><br>Develop sustainable instream flow criteria for spawning and incubation periods.<br><br>Develop and implement flow ramping protocols to protect all life stages of spring-run Chinook salmon.<br><br>Enhance watershed resiliency by identifying and implementing projects that would reduce the potential for, and magnitude of, a catastrophic wildfire, and restore forested areas within the watershed including riparian areas. | Spawning, Egg Incubation | Butte Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | |
| NS-28 | Reduce the number of temporary passage impediments installed to create swimming holes in Butte Creek near Chico; conduct associated public outreach projects. | Adult Immigration | Butte Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | |
| NS-29 | Identify stream reaches that have been most altered by anthropogenic factors and reconstruct a natural channel geometry scaled to current channel forming flows. | All | Butte Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | |
| NS-30 | Promote or create riparian buffer strips between the Butte Creek channel and adjacent land uses. | Juvenile Emigration, Summer/Winter Rearing | Butte Creek | PG&E/CalTrout Prioritized Actions List | No reference cited. | |
| NS-31 | Implement projects that consolidate and screen existing diversions where feasible. | Juvenile Emigration | Butte Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | |
| NS-32 | Retrofit dams on Little Butte Creek in order to provide for more storage to use for fisheries flows. | All | Little Butte Creek | HEA Steering Committee | No reference cited. | An earthquake retrofit is necessary and might be an opportunity to increase storage to benefit fisheries flows. This would primarily benefit steelhead. |
| NS-33 | Improve passage of chinook salmon & steelhead at dams on Deer Creek. | Adult Immigration | Deer Creek | PG&E/CalTrout Prioritized Actions List | Spring-run chinook salmon recovery brainstorming session (11/8/05). | Local support is questionable regarding landowners not associated with the watershed conservancy. |
| NS-34 | Construct fish ladder at upper Deer Creek falls. | Adult Immigration | Deer Creek | PG&E/CalTrout Prioritized Actions List | Spring-run chinook salmon recovery brainstorming session (11/8/05). | |

| Reference Number | Description of Action | Target Life Stage(s) | Stream | Source Document | Reference Cited in Source | Notes |
|---|---|---|---|---|---|---|
| NS-35 | Acquire water from willing sellers consistent with applicable guidelines or negotiate agreements to supplement instream flows in the lower ten miles of Deer Creek to ensure passage of adult and juvenile spring- and fall-run Chinook salmon and steelhead over three diversion dams. | Adult Immigration, Juvenile Emigration | Deer Creek | PG&E/CalTrout Prioritized Actions List | AFRP Restoration Plan (USFWS 2001) | Water exchange program is being funded through the 4-Pumps mitigation program. |
| NS-36 | Implement water exchange agreement with the Deer Creek Irrigation Company and the Stanford-Vina Irrigation District and dedicate fish passage flows (AFRP Website 2005). | Adult Immigration, Adult Holding | Deer Creek | NMFS Recovery Plan Co-Manager Review Draft | http://www.delta.dfg.ca.gov/afrp/ | |
| NS-37 | Permit and construct a state-of-the-art fish ladder that meets NMFS' adult fish passage criteria and install a new apron at the Cone-Kimball Diversion (AFRP Website 2005).<br><br>Install state-of-the-art fish ladder at Stanford-Vina Dam (AFRP Website 2005, NMFS 2007b).<br><br>Conduct fish passage evaluation at all agricultural diversions to determine if they meet NMFS' fish passage criteria.<br><br>Design and install state-of-the-art fish passage facilities at diversions that currently do not meet the passage criteria. Study feasibility of consolidating diversion points to minimize the number of diversions on Deer Creek. Based on this study, consolidate diversions where feasible.<br><br>Conduct a study designed to determine adult fish passage flows at critical riffles and fish ladders.<br><br>Develop a water exchange agreement with all water users to allow implementation of those flows. | Adult Immigration | Deer Creek | NMFS Recovery Plan Co-Manager Review Draft | Summary of Threats and Recovery Actions for Spring-Run and Winter-Run Chinook Salmon. (Notes from the Sacramento Salmon and Steelhead Recovery Workshop, May 22, 2007.) | Project to improve fish passage at Stanford-Vina Dam is being considered as part of Deer Creek Floodplain Study as of Oct 2008; projects to improve fish passage at DCID and Cone-Kimball diversion dams are being discussed between Deer Creek Watershed Conservancy and irrigation districts as of Oct 2008. |

| Reference Number | Description of Action | Target Life Stage(s) | Stream | Source Document | Reference Cited in Source | Notes |
|---|---|---|---|---|---|---|
| NS-38 | Enhance watershed resiliency by identifying and implementing projects that would reduce the potential for, and magnitude of a catastrophic wildfire, restore meadows (Deer Creek meadows, Childs meadows, Gurnsey Creek, and North Fork Deer Creek) to potentially increase summer flows and reduce local water temperatures, or increase riparian shade and reduce sources of chronic road-related erosion of sediment (Deer Creek Conservancy Watershed Report, U.S. Forest Service Long-term Anadromous Fish Conservation Strategy). | All | Deer Creek | NMFS Recovery Plan Co-Manager Review Draft | Deer Creek Watershed Existing Conditions Report.<br><br>U.S. Forest Service Long-term Anadromous Fish Conservation Strategy. | |
| NS-39 | Carry out a Deer Creek (upper) erosion reduction project (AFRP Website 2005).<br><br>Restore meadows and reduce stream channel incisement and bank erosion by modifying grazing practices and excluding cattle from nearshore zones, and reduce the potential for, and magnitude of a catastrophic wildfire, and reduce sources of chronic road-related erosion (U.S. Forest Service Long-term Anadromous Fish Conservation Strategy).<br><br>Decommission Fire Mountain Lodge Hydro-electric project, and remove the earthen dam, restore the stream channel, and obliterate project roads. | Spawning, Egg Incubation | Deer Creek | NMFS Recovery Plan Co-Manager Review Draft | U.S. Forest Service Long-term Anadromous Fish Conservation Strategy. | **Fire Mt Lodge; Notice of Application for…Establishing Procedural Schedule for Relicensing…: http://edocket.access.gpo.gov/2008/E8-10957.htm** |
| NS-40 | Build sediment retention structures; fortify streambanks with native vegetation. | Spawning, ,Egg Incubation | Deer Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | |
| NS-41 | Identify gravel starved areas in Deer Creek and implement gravel additions. Re-design highway 32 culvert crossing at Calf Creek to allow for unimpeded bedload transport. Conduct a spawning gravel augmentation feasibility study to increase available spawning habitat. Implement spawning gravel augmentation projects if the feasibility study determines that such projects will not cause adverse ecological impacts. | Spawning | Deer Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | |

| Reference Number | Description of Action | Target Life Stage(s) | Stream | Source Document | Reference Cited in Source | Notes |
|---|---|---|---|---|---|---|
| NS-42 | Implement projects to increase floodplain habitat availability to improve habitat conditions for juvenile rearing (NMFS 2007b). | Summer/Winter Rearing | Deer Creek | NMFS Recovery Plan Co-Manager Review Draft | Summary of Threats and Recovery Actions for Spring-Run and Winter-Run Chinook Salmon. (Notes from the Sacramento Salmon and Steelhead Recovery Workshop, May 22, 2007.) | |
| NS-43 | Renew long-term agreements to restore and preserve riparian habitats along Deer Creek. | Juvenile Emigration, Summer/Winter Rearing | Deer Creek | PG&E/CalTrout Prioritized Actions List | AFRP Restoration Plan (USFWS 2001) | |
| NS-44 | Restore a functional, seasonally inundated floodplain along lower Deer Creek to provide enhanced rearing habitat for spring-run Chinook salmon fry. | Summer/Winter Rearing | Deer Creek | PG&E/CalTrout Prioritized Actions List | Collaborative Group 2006. | |
| NS-45 | Identify and implement projects designed to improve downstream passage conditions for juveniles. | Juvenile Emigration | Deer Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | |
| NS-46 | Identify stream reaches that have been most altered by anthropogenic factors and reconstruct a natural channel geometry scaled to current channel forming flows. | All | Deer Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | |
| NS-47 | Ensure that all Feather River diversions have fish screens that meet NMFS' fish screen criteria. | Juvenile Emigration | Feather River | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | |
| NS-48 | Implement programs and measures designed to control non-native predatory fish (NMFS 2007b), including eradication programs for non-native predators (e.g., striped bass, largemouth bass, and smallmouth bass).<br><br>Implement projects to minimize predation at weirs, diversion dams, and related structures.<br><br>Improve nearshore refuge cover for salmonids to minimize predatory opportunities for striped bass and other non-native predators. | Juvenile Emigration | Feather/Yuba Rivers | NMFS Recovery Plan Co-Manager Review Draft | Summary of Threats and Recovery Actions for Spring-Run and Winter-Run Chinook Salmon. (Notes from the Sacramento Salmon and Steelhead Recovery Workshop, May 22, 2007.) | |
| NS-49 | Identify stream reaches that have been most altered by anthropogenic factors and reconstruct a natural channel geometry scaled to current channel forming flows. | All | Feather/Yuba Rivers | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | |
| NS-50 | Improve passage of chinook salmon & steelhead at dams on Mill Creek. | Adult Immigration | Mill Creek | PG&E/CalTrout Prioritized Actions List | Spring-run chinook salmon recovery brainstorming session (11/8/05). | |

| Reference Number | Description of Action | Target Life Stage(s) | Stream | Source Document | Reference Cited in Source | Notes |
|---|---|---|---|---|---|---|
| NS-51 | Supplement flows in Mill Creek with water acquired from willing sellers consistent with applicable guidelines or negotiate agreements to allow passage of juvenile and adult spring-, fall- and late-fall-run Chinook salmon and steelhead. | All | Mill Creek | PG&E/CalTrout Prioritized Actions List | AFRP Restoration Plan (USFWS 2001). | This action is potentially being included in the four pumps mitigation agreements. Wording has changed from original PG&E/Caltrout list from "Continue to provide flows..." to "Supplement flows..." |
| NS-52 | Conduct fish passage evaluation at all agricultural diversions to determine if they meet NMFS' fish passage criteria.<br><br>Design and install state-of-the-art fish passage facilities at diversions that currently do not meet the passage criteria.<br><br>Conduct a study designed to determine adult fish passage flows at critical riffles and fish ladders.<br><br>Develop a water exchange agreement with all water users to allow implementation of those flows. | Adult Immigration | Mill Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | |
| NS-53 | Enhance watershed resiliency by identifying and implementing projects that would reduce the potential for, and magnitude of a catastrophic wildfire, restore meadows to potentially increase summer flows and reduce local water temperatures, or increase riparian shade and reduce sources of chronic road-related erosion of sediment (Mill Creek Conservancy Watershed Report, U.S. Forest Service Long-term Anadromous Fish Conservation Strategy). | All | Mill Creek | NMFS Recovery Plan Co-Manager Review Draft | Mill Creek Watershed Management Strategy Report.<br><br>U.S. Forest Service Long-term Anadromous Fish Conservation Strategy. | |
| NS-54 | Restore meadows and reduce stream channel incisement and bank erosion by modifying grazing practices and excluding cattle from nearshore zones, and reduce the potential for, and magnitude of a catastrophic wildfire, and reduce sources of chronic road-related erosion (U.S. Forest Service Long-term Anadromous Fish Conservation Strategy). | Spawning, Egg Incubation | Mill Creek | NMFS Recovery Plan Co-Manager Review Draft | U.S. Forest Service Long-term Anadromous Fish Conservation Strategy. | |

| Reference Number | Description of Action | Target Life Stage(s) | Stream | Source Document | Reference Cited in Source | Notes |
|---|---|---|---|---|---|---|
| NS-55 | Work with State and Federal water acquisition programs to develop dedicated instream water; participate in the lower Mill Creek Watershed Restoration Project (AFRP Website 2005). | All | Mill Creek | NMFS Recovery Plan Co-Manager Review Draft | http://www.delta.dfg.ca.gov/afrp/ | |
| NS-56 | Build sediment retention structures; fortify streambanks with native vegetation. | Spawning, Egg Incubation | Mill Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | |
| NS-57 | Implement projects to increase floodplain habitat availability to improve habitat conditions for juvenile rearing (NMFS 2007b). | Summer/Winter Rearing | Mill Creek | NMFS Recovery Plan Co-Manager Review Draft | Summary of Threats and Recovery Actions for Spring-Run and Winter-Run Chinook Salmon. (Notes from the Sacramento Salmon and Steelhead Recovery Workshop, May 22, 2007.) | |
| NS-58 | Identify and implement projects designed to improve downstream passage conditions for juveniles. | Juvenile Emigration | Mill Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | |
| NS-59 | Identify stream reaches that have been most altered by anthropogenic factors and reconstruct a natural channel geometry scaled to current channel forming flows. | All | Mill Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | |
| NS-60 | Establish, restore, and maintain riparian habitat along the lower reaches of Mill Creek. | Juvenile Emigration, Summer/Winter Rearing | Mill Creek | PG&E/CalTrout Prioritized Actions List | AFRP Restoration Plan (USFWS 2001). | |
| NS-61 | Provide passage past Engelbright Dam for steelhead and Chinook salmon. | Adult Immigration, Spawning | Yuba River | PG&E/CalTrout Prioritized Actions List | Upper Yuba River Studies Program 2006 | Effect of reintroduction above Engelbright reservoir on other resources, particularly resident trout fisheries, is unknown. |
| NS-62 | Facilitate passage of spawning adult salmonids by maintaining appropriate flows through the fish ladders, or by modifying the fish ladders at Daguerre Point Dam. | Adult Immigration | Yuba River | PG&E/CalTrout Prioritized Actions List | AFRP Restoration Plan (USFWS 2001) | |
| NS-63 | Construct improved fish passage facilities at Daguerre Point Dam to provide for segregation of adult spring-run and fall-run chinook salmon. | Spawning, Egg Incubation | Yuba River | PG&E/CalTrout Prioritized Actions List | Spring-run chinook salmon recovery brainstorming session (11/8/05). | It is difficult to determine how segregation would contribute to the HEA threshold. Impact to migrating steelhead is also a concern. |
| NS-64 | Collaboratively design the Daguerre Point Dam fish ladder passage engineering and design of the preferred alternative described in DWR and Corps (2003) (AFRP Website 2005). | Adult Immigration | Yuba River | NMFS Recovery Plan Co-Manager Review Draft | Daguerre Point Dam Fish Passage Improvement Project 2002 Fisheries Study. | |
| NS-65 | Facilitate passage of juvenile salmonids by modifying the dam face of Daguerre Point Dam. | Adult Immigration | Yuba River | PG&E/CalTrout Prioritized Actions List | AFRP Restoration Plan (USFWS 2001) | |

| Reference Number | Description of Action | Target Life Stage(s) | Stream | Source Document | Reference Cited in Source | Notes |
|---|---|---|---|---|---|---|
| NS-66 | Operate reservoirs in the Yuba River basin to provide adequate water temperatures for anadromous fish. | All | Yuba River | PG&E/CalTrout Prioritized Actions List | AFRP Restoration Plan (USFWS 2001). | |
| NS-67 | Implement actions to enhance habitat conditions and improve access within the area above Englebright Dam, including increasing minimum flows, providing passage at Our House, New Bullards Bar, and Log Cabin dams, and assessing feasibility of passage improvement at natural barriers. Design and conduct an experimental fish passage program to evaluate adult distribution, survival, spawning, and production in habitats above Englebright Dam. If the experimental fish passage program demonstrates that passage above Englebright Dam can substantively contribute to the long-term viability of the ESU, then develop and implement long-term fish passage programs. | Adult Immigration, Spawning | Yuba River | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | |
| NS-68 | Conduct gravel additions above and below Narrows Pool (Corps mitigation) (AFRP Website 2005). | Spawning | Yuba River | NMFS Recovery Plan Co-Manager Review Draft | http://www.delta.dfg.ca.gov/afrp/ | |
| NS-69 | Improve efficiency of screening devices at Brophy-South Yuba water diversion and other unscreened diversions. | Juvenile Emigration | Yuba River | PG&E/CalTrout Prioritized Actions List | AFRP Restoration Plan (USFWS 2001). | |
| NS-70 | Construct or improve the fish bypasses at Hallwood-Cordua and Brophy-South Yuba water diversion. | All | Yuba River | PG&E/CalTrout Prioritized Actions List | AFRP Restoration Plan (USFWS 2001). | |
| NS-71 | Develop and implement a large woody material restoration program along the lower Yuba River utilizing sources of wood that enter upstream reservoirs. | Juvenile Emigration, Summer/Winter Rearing | Yuba River | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | |
| NS-72 | Implement flow fluctuation and ramping rates found to be protective of embryos and juveniles by the fry stranding and redd dewatering study. | Egg Incubation, Juvenile Emigration, Summer/Winter Rearing | Yuba River | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | |
| NS-73 | Reduce and control flow fluctuations to avoid and minimize adverse effects to juvenile salmonids. | Juvenile Emigration, Summer/Winter Rearing | Yuba River | PG&E/CalTrout Prioritized Actions List | AFRP Restoration Plan (USFWS 2001). | |

| Reference Number | Description of Action | Target Life Stage(s) | Stream | Source Document | Reference Cited in Source | Notes |
|---|---|---|---|---|---|---|
| NS-74 | Identify and implement projects designed to minimize predation on juvenile salmonids at Daguerre Point Dam and associated structures.<br><br>Implement programs and measures designed to control non-native predatory fish (NMFS 2007b), including eradication programs for non-native predators (e.g., striped bass, largemouth bass, and smallmouth bass).<br><br>Improve nearshore refuge cover for salmonids to minimize predatory opportunities for striped bass and other non-native predators. | Juvenile Emigration, Summer/Winter Rearing | Yuba River | NMFS Recovery Plan Co-Manager Review Draft | Summary of Threats and Recovery Actions for Spring-Run and Winter-Run Chinook Salmon. (Notes from the Sacramento Salmon and Steelhead Recovery Workshop, May 22, 2007.) | |
| NS-75 | Purchase conservation easements (AFRP 2006b) adjacent to the Yuba River and manage those easements as seasonal floodplain habitats.<br><br>Implement projects to increase floodplain habitat availability to improve habitat conditions for juvenile rearing (NMFS 2007b). | Summer/Winter Rearing | Yuba River | NMFS Recovery Plan Co-Manager Review Draft | Summary of Threats and Recovery Actions for Spring-Run and Winter-Run Chinook Salmon. (Notes from the Sacramento Salmon and Steelhead Recovery Workshop, May 22, 2007.) | No reference cited for the AFRP 2006b in the Recovery Plan. |
| NS-76 | Purchase streambank conservation easements in the Yuba River to improve salmonid habitat and instream cover. | Juvenile Emigration, Summer/Winter Rearing | Yuba River | PG&E/CalTrout Prioritized Actions List | AFRP Restoration Plan (USFWS 2001). | |

| Reference Number | Description of Action | Target Life Stage(s) | Stream | Source Document | Reference Cited in Source | Notes |
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| **Basalt and Porus Lava Spring-Run Chinook Salmon Diversity Group Threats and Associated Recovery Actions** | | | | | | |
| B-1 | Implement Phase 1(b) of the package of passage, screening, and flow actions defined for the Battle Creek Restoration project, as defined by the Memorandum of Understanding. | Adult Immigration | Battle Creek | PG&E/CalTrout Prioritized Actions List | Battle Creek Restoration Plan (Kier and Associates 1999). | |
| B-2 | Implement Phase 2 of the package of passage, screening, and flow actions defined for the Battle Creek Restoration project, as defined by the Memorandum of Understanding. | All | Battle Creek | PG&E/CalTrout Prioritized Actions List | Battle Creek Restoration Plan (Kier and Associates 1999). | |
| B-3 | Install pipeline connections between powerhouses and diversion-canal intakes to prevent trans-basin water diversions from causing false attraction of anadromous salmonids from the North Fork to the South Fork. [1] | Adult Immigration | Battle Creek | PG&E/CalTrout Prioritized Actions List | Battle Creek Restoration Plan (Kier and Associates 1999). | The cost of installing a pipeline connection at Coleman has been estimated at approximately $18 M, making this project seem unreasonably expensive. Additionally, the landownder in the vicinity of the upper pipeline is opposed to any construction in his viewshed. |
| B-4 | Develop and implement pulse flow schedules during peak migration periods for years with low water availability. | Adult Immigration | Battle Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | |
| B-5 | Install state-of-the-art ladders at, or remove small dams on the South Fork of Battle Creek to provide fish passage (NMFS 2007b). | Adult Immigration | Battle Creek | NMFS Recovery Plan Co-Manager Review Draft | Summary of Threats and Recovery Actions for Spring-Run and Winter-Run Chinook Salmon. (Notes from the Sacramento Salmon and Steelhead Recovery Workshop, May 22, 2007.) | |
| B-6 | Increase streamflows as specified in the Battle Creek Salmon and Steelhead Restoration Plan (NMFS 2007b). | All | Battle Creek | NMFS Recovery Plan Co-Manager Review Draft | Summary of Threats and Recovery Actions for Spring-Run and Winter-Run Chinook Salmon. (Notes from the Sacramento Salmon and Steelhead Recovery Workshop, May 22, 2007.) | |
| B-7 | Increase flow releases from remaining diversion dams affecting anadromous fish on Battle Creek as per the Battle Creek Restoration Plan (CALFED 2007).<br><br>Avoid implementation of additional water projects (i.e., FERC permits) that are detrimental to the goals and objectives of the Battle Creek Salmon and Steelhead Restoration Plan. | Adult Immigration, Adult Holding | Battle Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | No reference cited for CALFED 2007 in the Recovery Plan. |
| B-8 | Provide anadromous fish passage as specified in the Battle Creek Salmon and Steelhead Restoration Plan (CALFED 2007). | Adult Immigration | Battle Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | No reference cited for CALFED 2007 in the Recovery Plan. |

| Reference Number | Description of Action | Target Life Stage(s) | Stream | Source Document | Reference Cited in Source | Notes |
|---|---|---|---|---|---|---|
| B-9 | Implement the Battle Creek Salmon and Steelhead Restoration Plan.<br><br>Modernize/upgrade PG&E facilities to reduce the potential for flow fluctuations and outages. | All | Battle Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | |
| B-10 | Encourage conservation easements and other incentives to retain large blocks of land under private ownership that continue to buffer Battle Creek fish populations from intense types of streamside land management practices and human disturbance. | All | Battle Creek | PG&E/CalTrout Prioritized Actions List | Battle Creek Restoration Plan (Kier and Associates 1999). | |
| B-11 | Encourage riparian, stream channel, and fish habitat restoration projects following ecosystem-based approaches on private lands. | All | Battle Creek | PG&E/CalTrout Prioritized Actions List | Battle Creek Restoration Plan (Kier and Associates 1999). | |
| B-12 | Develop and increase application of alternative diversion technologies that eliminate entrainment. | Juvenile Emigration | Battle Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | |
| B-13 | Implement programs and measures designed to control non-native predatory fish (NMFS 2007b), including eradication programs for non-native predators (e.g., striped bass, largemouth bass, and smallmouth bass).<br><br>Implement projects to minimize predation at weirs, diversion dams, and related structures. Improve nearshore refuge cover for salmonids to minimize predatory opportunities for striped bass and other non-native predators. | Juvenile Emigration, Summer/Winter Rearing | Battle Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | |
| B-14 | Encourage land management to protect against catastrophic wildfires through fuel reduction. | All | Battle Creek | PG&E/CalTrout Prioritized Actions List | Battle Creek Restoration Plan (Kier and Associates 1999). | |

| Reference Number | Description of Action | Target Life Stage(s) | Stream | Source Document | Reference Cited in Source | Notes |
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| B-15 | Conduct feasibility studies for allowing spring-run Chinook salmon access to habitat above Shasta Dam, including assessing habitat suitability and passage logistics (i.e., getting immigrating adults above the dam and emigrating juveniles below it). If the feasibility studies suggest that fish passage can be successful, then design and conduct an experimental fish passage program evaluating adult distribution, survival, spawning, and production in habitats above Shasta Dam.<br><br>If the experimental fish passage program demonstrates that passage above Shasta dam can substantively contribute to the long-term viability of the ESU, then develop and implement long-term fish passage programs. | Adult Immigration, Adult Holding, Spawning | Sacramento River | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | |
| B-16 | Implement an annual trap-and-haul operation to restore access to existing and restored habitat in tributaries upstream of Shasta Dam | Adult Immigration, Adult Holding, Spawning | Sacramento River | PG&E/CalTrout Prioritized Actions List | Calfed Bay Delta Program 2006 | |
| B-17 | Maintain the gates-up position to prevent passage impediments to listed species. | Adult Immigration | Sacramento River/Battle Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | |
| B-18 | Conduct periodic (e.g., every 5 years) spawning gravel assessments in the upper Sacramento River (i.e., above RBDD) and implement gravel augmentation projects, as necessary. | Spawning | Sacramento River | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | |
| B-19 | Modify gravel pits and mounds to ensure full drainage of these features to allow flooding while preventing stranding and warm water predator habitat. | Juvenile Emigration, Summer/Winter Rearing | Upper Sacramento River | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | The Recovery Plan mentions this action in reference to the juveniles produced in the Sacramento River. |
| B-20 | Restore the current Lake Red Bluff footprint to riparian habitat. | All | Upper Sacramento River | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | The Recovery Plan mentions this action in reference to the juveniles produced in the Sacramento River. |

| Reference Number | Description of Action | Target Life Stage(s) | Stream | Source Document | Reference Cited in Source | Notes |
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| **Northwestern California Spring-Run Chinook Salmon Threats and Associated Recovery Actions** | | | | | | |
| NWC-1 | Enhance watershed resiliency by identifying and implementing projects that would reduce the potential for, and magnitude of a catastrophic wildfire, restore meadows to potentially increase summer flows and reduce local water temperatures, or increase riparian shade. | All | Beegum Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | |
| NWC-2 | Develop and implement a spawning gravel augmentation plan. | Spawning | Beegum Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | |
| NWC-3 | Eliminate sources of chronic sediment delivery from roads and other near stream development by out-sloping roads, constructing diversion prevention dips, replacing under-sized culverts and applying other storm proofing guidelines. | Spawning, Egg Incubation | Beegum Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | |
| NWC-4 | Develop cooperative water use agreements (e.g., groundwater exchange agreements) with local water users to provide flows during the immigration life stage. | Adult Immigration | Beegum Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | |
| NWC-5 | Inject LWD and boulders in the canyon reach of Clear Creek to induce gravel deposition to support pocket spawning by salmonids. | Spawning | Clear Creek | PG&E/CalTrout Prioritized Actions List | Collaborative Group 2006. | |
| NWC-6 | Additional Gravel Supplementation in the reaches of Clear Creek directly below Whiskeytown Dam. | Spawning | Clear Creek | HEA Steering Committee | No reference cited. | This would not be self-sustaining. It would need to be redone periodically. |
| NWC-7 | Develop a spawning gravel budget and implement an augmentation plan and use flow management to optimize spawning weighted usable area in consideration of hydrologic limitations and other species (e.g., steelhead) and life stage requirements. Develop a spawning gravel budget and implement an augmentation plan. | Spawning | Clear Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | |
| NWC-8 | Supplement flows in Clear Creek in order to provide a more natural flow regime and encourage gravel dispersal. | Spawning | Clear Creek | HEA Steering Committee | No reference cited. | This action would primarily include paying for the forfeited power generation. |

| Reference Number | Description of Action | Target Life Stage(s) | Stream | Source Document | Reference Cited in Source | Notes |
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| NWC-9 | Increase stream flows as needed to reduce water temperatures (NMFS 2007b).<br><br>Develop a real time water temperature model to track the coldwater pool in Whiskeytown Reservoir and budget releases to Clear Creek to meet a daily water temperature of 60°F at the Igo gauge from June 1 to September 15 and 56°F from September 15 to October 31.<br><br>Enhance watershed resiliency by identifying and implementing projects that would reduce the potential for, and magnitude of a catastrophic wildfire, restore meadows to potentially increase summer flows and reduce local water temperatures, or increase riparian shade. | All | Clear Creek | NMFS Recovery Plan Co-Manager Review Draft | Summary of Threats and Recovery Actions for Spring-Run and Winter-Run Chinook Salmon. (Notes from the Sacramento Salmon and Steelhead Recovery Workshop, May 22, 2007.) | |
| NWC-10 | Conduct a passage feasibility study, including an assessment of potential habitat above Whiskeytown Dam. | Adult Immigration, Adult Holding, Spawning | Clear Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | |
| NWC-11 | Develop and implement flow ramping protocols to protect all life stages of spring-run Chinook salmon. | All | Clear Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | |
| NWC-12 | Develop and implement optimal pulse flow schedules and increase flow allocation for Clear Creek in years with low water availability. | All | Clear Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | |
| NWC-13 | Eliminate sources of chronic sediment delivery from roads and other near stream development by out-sloping roads, constructing diversion prevention dips, replacing under-sized culverts and applying other storm proofing guidelines | Spawning, Egg Incubation | Clear Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | |
| NWC-14 | Develop a cooperative program to improve flow on Clear Creek by increasing releases from Whiskeytown Dams (USFWS 1997). | All | Clear Creek | NMFS Recovery Plan Co-Manager Review Draft | Abundance and Survival of Juvenile Chinook Salmon in the Sacramento-San Joaquin Estuary, 1994 Annual Progress Report. | |

| Reference Number | Description of Action | Target Life Stage(s) | Stream | Source Document | Reference Cited in Source | Notes |
|---|---|---|---|---|---|---|
| NWC-15 | Increase integration of the State and Federal water projects through shared storage and conveyance agreements.<br><br>Negotiate agreements with landowners and Federal and State agencies to provide additional instream flows or purchase water rights (AFRP website 2005).<br><br>Implement projects that improve fish passage between the Sacramento River and flood bypasses. | Adult Immigration | Clear Creek | NMFS Recovery Plan Co-Manager Review Draft | http://www.delta.dfg.ca.gov/afrp/ | |
| NWC-16 | Implement Lower Clear Creek Floodway Rehabilitation Project (Phase 3B) and other projects designed to improve juvenile rearing habitat (CALFED 2007). | Summer/Winter Rearing | Clear Creek | NMFS Recovery Plan Co-Manager Review Draft | | No reference cited for CALFED 2007 in the Recovery Plan. |
| NWC-17 | Facilitate watershed protection and restoration to reduce water temperatures and siltation to improve holding, spawning, and rearing habitats for salmonids. | All | Cottonwood Creek | PG&E/CalTrout Prioritized Actions List | AFRP Restoration Plan (USFWS 2001). | |
| NWC-18 | Protect/enhance existing riparian habitat and corridors (NMFS 2007b).<br><br>Implement non-native plant (e.g. Arundo) eradication plan. | Juvenile Emigration, Summer/Winter Rearing | Cottonwood Creek | NMFS Recovery Plan Co-Manager Review Draft | Summary of Threats and Recovery Actions for Spring-Run and Winter-Run Chinook Salmon. (Notes from the Sacramento Salmon and Steelhead Recovery Workshop, May 22, 2007.) | This action, while on Cottonwood Creek, is mentioned in the Recovery Plan as benefiting Beegum Creek |
| NWC-19 | Re-establish natural channel morphology by: (1) applying NMFS gravel mining criteria to all gravel mining projects; (2) integrating natural morphological features and functions into bank protection and other stream side development projects; and (3) implementing non-native plant (e.g. Arundo) eradication plan. | All | Cottonwood Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | This action, while on Cottonwood Creek, is mentioned in the Recovery Plan as benefiting Beegum Creek |
| NWC-20 | Establish, restore, and maintain riparian habitat on Cottonwood Creek. | Juvenile Emigration, Summer/Winter Rearing | Cottonwood Creek | PG&E/CalTrout Prioritized Actions List | AFRP Restoration Plan (USFWS 2001). | |

| Reference Number | Description of Action | Target Life Stage(s) | Stream | Source Document | Reference Cited in Source | Notes |
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| NWC-21 | Modify gravel mining methods to reduce their effects on salmonid spawning habitats; employ the most ecologically sound timber extraction practices by implementing the Forest Plan on federal lands within the drainage; modify and employ the most ecologically sound forestry and grazing practices by implementing the Forest Plan on federal lands and through partenerships on private and state-owned land within the drainage to reduce fine sediment loading; reduce use of seasonal diversion dams that may be barriers to migrating Chinook salmon and steelhead. | All | Thomes Creek | PG&E/CalTrout Prioritized Actions List | AFRP Restoration Plan (USFWS 2001). | Four actions from the PG&E/Caltrout effort were combined. In order for spring run to benefit from restoration actions on Thomes Creek, all of these actions would have to be carried out. |
| NWC-22 | Flow consolidation through reduction of braided channels. | All | Thomes Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | |
| NWC-23 | Enhance watershed resiliency by identifying and implementing projects that would reduce the potential for, and magnitude of a catastrophic wildfire, restore meadows to potentially increase summer flows and reduce local water temperatures, or increase riparian shade. | All | Thomes Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | |
| NWC-24 | Develop and implement a spawning gravel augmentation plan. | Spawning | Thomes Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | |

| Reference Number | Description of Action | Target Life Stage(s) | Stream | Source Document | Reference Cited in Source | Notes |
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| **Sacramento River Basinwide** | | | | | | |
| SBW-1 | Implement bank revetment removal programs and projects and breach or remove abandoned levees during set-back levee projects.<br><br>Implement projects that acquire strategic floodplain easements to re-establish floodplain connectivity in areas constricted by levees.<br><br>Restore a continuous 100-mile stretch of ecologically viable riparian habitat to flood-prone lands along the river between Red Bluff and Colusa (The Nature Conservancy Website). | Juvenile Emigration, Summer/Winter Rearing | Lower Sacramento River | NMFS Recovery Plan Co-Manager Review Draft | http://www.nature.org/wherewework/northamerica/states/california/ | |
| SBW-2 | Restore a continuous 100-mile stretch of ecologically viable riparian habitat to flood-prone lands along the river between Red Bluff and Colusa (The Nature Conservancy Website).<br><br>Implement bank revetment removal programs and projects and breach or remove abandoned levees during set-back levee projects. | Juvenile Emigration, Summer/Winter Rearing | Middle Sacramento River | NMFS Recovery Plan Co-Manager Review Draft | http://www.nature.org/wherewework/northamerica/states/california/ | |
| SBW-3 | Promote native riparian (e.g., willows) species through eradication of non-native species (e.g., Arundo, tamarisk).<br><br>Modify vegetation maintenance practices to encourage riparian growth and establish a native vegetated corridor in currently unvegetated/leveed reaches of the lower Sacramento River especially between Colusa and Verona.<br><br>Restore a continuous 85-mile stretch of riparian habitat of an appropriate width to maintain ecologically viable function to flood-prone lands along both banks of the river between Colusa and Sacramento. | Juvenile Emigration, Summer/Winter Rearing | Lower Sacramento River | NMFS Recovery Plan Co-Manager Review Draft | | |

| Reference Number | Description of Action | Target Life Stage(s) | Stream | Source Document | Reference Cited in Source | Notes |
|---|---|---|---|---|---|---|
| SBW-4 | Modify vegetation maintenance practices to encourage riparian growth and establish a native vegetated corridor in currently unvegetated/leveed reaches of the middle Sacramento River.<br><br>Restore a continuous 100-mile stretch of riparian habitat of an appropriate width to maintain ecologically viable function to flood-prone lands along both banks of the river between Red Bluff and Colusa (The Nature Conservancy Website 2007).<br><br>Set back training walls and restore floodplain function in gold fields and other appropriate floodplain zones.<br><br>Implement bank revetment removal programs and projects and breach or remove abandoned levees during set-back levee projects.<br><br>Implement gravel injection program below Englebright Dam to restore geofluvial processes.<br><br>Create and restore side-channel habitats to increase the quantity and quality of off-channel rearing (and spawning) areas. | Juvenile Emigration, Summer/Winter Rearing | Middle Sacramento River | NMFS Recovery Plan Co-Manager Review Draft | http://www.nature.org/wherewework/northamerica/states/california/ | |
| SBW-5 | Implement programs and measures designed to control non-native predatory fish (NMFS 2007b), including eradication programs for non-native predators (e.g., striped bass, largemouth bass, and smallmouth bass).<br><br>Implement projects to minimize predation at weirs (e.g., Freemont Weir), diversion dams, and related structures.<br><br>Improve nearshore refuge cover for salmonids to minimize predatory opportunities for striped bass and other non-native predators. | Juvenile Emigration, Summer/Winter Rearing | Lower Sacramento River | NMFS Recovery Plan Co-Manager Review Draft | Summary of Threats and Recovery Actions for Spring-Run and Winter-Run Chinook Salmon. (Notes from the Sacramento Salmon and Steelhead Recovery Workshop, May 22, 2007.) | |

| Reference Number | Description of Action | Target Life Stage(s) | Stream | Source Document | Reference Cited in Source | Notes |
|---|---|---|---|---|---|---|
| SBW-6 | Implement programs and measures designed to control non-native predatory fish (NMFS 2007b), including eradication programs for non-native predators (e.g., striped bass, largemouth bass, and smallmouth bass).<br><br>Implement projects to minimize predation at weirs, diversion dams, and related structures (e.g., GCID).<br><br>Improve nearshore refuge cover for salmonids to minimize predatory opportunities for striped bass and other non-native predators. | Juvenile Emigration, Summer/Winter Rearing | Middle Sacramento River | NMFS Recovery Plan Co-Manager Review Draft | Summary of Threats and Recovery Actions for Spring-Run and Winter-Run Chinook Salmon. (Notes from the Sacramento Salmon and Steelhead Recovery Workshop, May 22, 2007.) | |
| SBW-7 | Implement projects that consolidate and screen existing diversions where feasible. | Juvenile Emigration | Middle Sacramento River | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | |
| SBW-8 | Implement actions designed to decrease water temperatures in Sacramento River tributaries during late-spring through early fall, thereby decreasing thermal loading to the Sacramento River. | All | Lower Sacramento River | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | |
| SBW-9 | Implement actions designed to decrease water temperatures in Sacramento River tributaries during late-spring through early fall, thereby decreasing thermal loading to the Sacramento River. | All | Middle Sacramento River | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | |
| SBW-10 | Develop and implement pulse flow schedules during peak migration periods for years with low water availability. | Adult Immigration | Middle Sacramento River | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | |
| SBW-11 | Develop and increase application of alternative diversion technologies that eliminate entrainment.<br><br>Implement projects that consolidate and screen existing diversions where feasible. | Juvenile Emigration | Lower Sacramento River | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | |
| SBW-12 | Develop and increase application of alternative diversion technologies that eliminate entrainment.<br><br>Implement projects that consolidate and screen existing diversions where feasible. | Juvenile Emigration | Middle Sacramento River | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | |

| Reference Number | Description of Action | Target Life Stage(s) | Stream | Source Document | Reference Cited in Source | Notes |
|---|---|---|---|---|---|---|
| SBW-13 | Implement programs and measures designed to control non-native predatory fish (NMFS 2007b), including eradication programs for non-native predators (e.g., striped bass, largemouth bass, and smallmouth bass).<br><br>Implement projects to minimize predation at weirs, diversion dams, and related structures (RBDD and ACID).<br><br>Improve nearshore refuge cover for salmonids to minimize predatory opportunities for striped bass and other non-native predators. | Juvenile Emigration, Summer/Winter Rearing | Upper Sacramento River | NMFS Recovery Plan Co-Manager Review Draft | Summary of Threats and Recovery Actions for Spring-Run and Winter-Run Chinook Salmon. (Notes from the Sacramento Salmon and Steelhead Recovery Workshop, May 22, 2007.) | |
| SBW-14 | Implement projects that acquire strategic floodplain easements to re-establish floodplain connectivity in areas constricted by levees. | Summer/Winter Rearing | Middle Sacramento River | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | The Recovery Plan mentions this action in reference to the juveniles produced in the Sacramento River. |
| SBW-15 | Create a flood bypass downstream of Mill and/or Deer creeks specifically to promote spring-run Chinook salmon fry rearing. | Summer/Winter Rearing | Middle Sacramento River | PG&E/CalTrout Prioritized Actions List | Stillwater Sciences 2006. | |
| SBW-16 | Manage spring flows in the mainstem Sacramento River to inundate shallow water habitats within the bankfull channel. | Summer/Winter Rearing, Juvenile Emigration | Middle Sacramento River | PG&E/CalTrout Prioritized Actions List | Stillwater Sciences 2006. | |
| SBW-17 | Restore riparian corridors in lower mainstem Sacramento River between Colusa and Collinsville | Summer/Winter Rearing, Juvenile Emigration | Lower Sacramento River | PG&E/CalTrout Prioritized Actions List | Collaborative Group 2006. | |
| SBW-18 | Pursue opportunities, consistent with efforts conducted pursuant to Senate Bill 1086 (SB 1086), to create a 50,000-acre meander belt from Keswick Dam to Colusa to recruit gravel and large woody debris, to moderate temperatures and to enhance nutrient input. | All | Upper /Middle Sacramento River | PG&E/CalTrout Prioritized Actions List | AFRP Restoration Plan (USFWS 2001). | |

Appendix C2

# Working List of Potential Actions

## Working List of Potential Habitat Expansion Actions

The following non-prioritized list of actions has been compiled by the HEA Steering Committee based on the potential of the actions to help satisfy requirements of the Habitat Expansion Agreement. The working list is pre-decisional and does not necessarily represent actions that will be selected by the HEA Steering Committee to include in the Draft Habitat Expansion Plan. Nothing precludes other actions, not currently included in the list, from being considered.

| Reference* Number | Description of Action | Target Life Stage(s) | Stream | Source | Reference Cited in Source | Notes | Contribution to HET (H/L) |
|---|---|---|---|---|---|---|---|
| **Northern Sierra Nevada Spring-Run Salmon Diversity Group** | | | | | | | |
| NS-1 | Supplement flows in Antelope Creek with water acquired from willing sellers consistent with applicable guidelines or negotiate agreements to allow passage of juvenile and adult spring-run Chinook salmon and steelhead. | All | Antelope Creek | PG&E/CalTrout Prioritized Actions List | AFRP Restoration Plan (USFWS 2001) | Economic feasibility and level of local/political support for flow supplementation are unknown. Additionally, the benefit of flow supplementation to maintenance of spatial separation is unclear. | L |
| NS-2 | Enhance watershed resiliency by identifying and implementing projects that would reduce the potential for, and magnitude of a catastrophic wildfire, restore meadows to potentially increase summer flows and reduce local water temperatures, or increase riparian shade. | All | Antelope Creek | NMFS Recovery Plan Co-Manager Review Draft | U.S. Forest Service Long-Term Anadromous Fish Conservation Strategy | Questionable match (fire) and additional information needed (meadows). | L |
| NS-3 | Conduct fish passage evaluation at all agricultural diversions to determine if they meet NMFS' fish passage criteria. Design and install state-of-the-art fish passage facilities at diversions that currently do not meet the passage criteria. | Adult Immigration | Antelope Creek | NMFS Recovery Plan Co-Manager Review Draft | http://www.delta.dfg.ca.gov/afrp/ | The Edwards Dam Ladder construction project was completed in October 2007. Juvenile bypass facilities are still needed as of October 2008. | L |
| NS-76 | Install Juvenile Bypass at the Edwards Dam Ladder. | Juvenile Emigration | Antelope Creek | Questionnaire | USFWS Final Restoration Plan for the Anadromous Fish Restoration Program (2001) | AFRP funded a feasibility study, environmental documentation, permits, and design for a solution at this site in 2008. Implementation can begin in 2010 but funding needed. | L |
| NS-77 | Conduct Antelope Creek valley floor channel analysis and implement recommended actions. | Adult Immigration, Juvenile Emigration | Antelope Creek | Questionnaire | USFWS Final Restoration Plan for the Anadromous Fish Restoration Program (2001) | | L |
| NS-78 | Reduce sources of chronic road related erosion of sediment. | All | Antelope Creek | Comment Form | | On-going activity. | L |
| NS-5 | Improve passage conditions at Paynes crossing to allow upstream passage during low flows. | Adult Immigration, Adult Holding | Antelope Creek | NMFS Recovery Plan Co-Manager Review Draft; Questionnaire | Summary of Threats and Recovery Actions for Spring-Run and Winter-Run Chinook Salmon (Notes from the Sacramento Salmon and Steelhead Recovery Workshop, May 22, 2007) | Also referred to as Tehama Wildlife Area crossing. AFRP is currently funding a fish passage feasibility study at this site, but as of October 2008 funding has not been identified for construction. | L |
| NS-6 | Identify gravel starved areas in Antelope Creek and implement gravel additions. | Spawning | Antelope Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited | Issue? USFS favors correcting undersized culverts to improve natural bedload instead. | L |
| NS-7 | Build sediment retention structures; fortify streambanks with native vegetation. | Spawning, Egg Incubation | Antelope Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited | Issue? | L |

*Reference numbers are not necessarily in consecutive order, but actions are grouped by watershed.

| Reference* Number | Description of Action | Target Life Stage(s) | Stream | Source | Reference Cited in Source | Notes | Contribution to HET (H/L) |
|---|---|---|---|---|---|---|---|
| NS-8 | Implement bank revetment removal programs and projects and breach or remove abandoned levees during set-back levee projects. | Summer/Winter Rearing, Juvenile Emigration | Antelope Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited | Issue? | L |
| NS-9 | Implement projects to increase floodplain habitat availability to improve habitat conditions for juvenile rearing. | Summer/Winter Rearing | Antelope Creek | NMFS Recovery Plan Co-Manager Review Draft | Summary of Threats and Recovery Actions for Spring-Run and Winter-Run Chinook Salmon (Notes from the Sacramento Salmon and Steelhead Recovery Workshop, May 22, 2007) | Additional information needed. | L |
| NS-10 | Implement projects that cooperatively work with landowners to modify existing diversions so that fish do not become entrained in agricultural fields. | Juvenile Emigration | Antelope Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited | Additional information needed. | L |
| | | | | | | | |
| NS-12 | Remove the partial barrier (old agricultural dam) approximately 0.4 river miles downstream of Higgins Hole, located on private property. | Adult Immigration | Big Chico Creek | HEA Steering Committee | No reference cited | Fish passage evaluation has not been done for this site. Additional information needed. | L |
| NS-13 | Conduct Fish Passage evaluation at all dams and diversions to determine if they meet NMFS fish passage criteria. Design and install state-of-the-art fish passage facilities at diversions (1-mile dam, 5-mile dam) that currently do not meet the passage criteria. | Adult Immigration | Big Chico Creek | NMFS Recovery Plan Co-Manager Review Draft | http://www.delta.dfg.ca.gov/afrp/ | | L |
| NS-14 | Implement Iron Canyon Fish Ladder Rehabilitation Project. | Adult Immigration | Big Chico Creek | PG&E/CalTrout Prioritized Actions List; Questionnaires | AFRP Restoration Plan (USFWS 2001) | City of Chico intends to adopt a Mitigated Negative Declaration for the project. Final report on the repair and construction is complete. CEQA complete and permitting is underway. | H |
| NS-16 | Protect spring-run Chinook salmon summer holding pools in Big Chico Creek by obtaining from willing sellers titles or conservation easements on lands adjacent to the pools. | Adult Holding | Big Chico Creek | PG&E/CalTrout Prioritized Actions List | AFRP Restoration Plan (USFWS 2001) | Benefit of this action would depend on the implementation of the Iron Canyon Fish Ladder project. Cost would be dependent on the landowners' willingness to sell. Additional information needed. | L |
| NS-17 | Enhance watershed resiliency by identifying and implementing projects that would reduce the potential for, and magnitude of a catastrophic wildfire, restore meadows to potentially increase summer flows and reduce local water temperatures, or increase riparian shade. | All | Big Chico Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited | | L |
| NS-19 | Identify stream reaches that have been most altered by anthropogenic factors and reconstruct a natural channel geometry scaled to current channel forming flows. | All | Big Chico Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited | Additional information needed. | L |
| NS-20 | Eliminate sources of chronic sediment delivery from roads and other near stream development by out-sloping roads, constructing diversion prevention dips, replacing under-sized culverts and applying other storm proofing guidelines. | Egg Incubation | Big Chico Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited | Additional information needed. | L |

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| Reference* Number | Description of Action | Target Life Stage(s) | Stream | Source | Reference Cited in Source | Notes | Contribution to HET (H/L) |
|---|---|---|---|---|---|---|---|
| NS-21 | Implement projects to increase floodplain habitat availability to improve habitat conditions for juvenile rearing. | Summer/Winter Rearing | Big Chico Creek | NMFS Recovery Plan Co-Manager Review Draft | Summary of Threats and Recovery Actions for Spring-Run and Winter-Run Chinook Salmon (Notes from the Sacramento Salmon and Steelhead Recovery Workshop, May 22, 2007) | Additional information needed. | L |
| NS-22 | Cooperate with local landowners to encourage revegetation of denuded stream reaches; and establish, restore, and maintain riparian habitat on Big Chico Creek. | Juvenile Emigration, Summer/Winter Rearing | Big Chico Creek | PG&E/CalTrout Prioritized Actions List | AFRP Restoration Plan (USFWS 2001) | Additional information needed. | L |
| | | | | | | | |
| NS-23 | Purchase existing water rights from willing sellers. | All | Butte Creek | PG&E/CalTrout Prioritized Actions List | AFRP Restoration Plan (USFWS 2001) | All Lower Butte Creek actions need to be investigated to determine if the actions were carried out in previous restoration activities. | L |
| NS-24 | Enhance watershed resiliency by identifying and implementing projects that would reduce the potential for, and magnitude of a catastrophic wildfire, restore meadows to potentially increase summer flows and reduce local water temperatures, or increase riparian shade. | All | Butte Creek | NMFS Recovery Plan Co-Manager Review Draft | U.S. Forest Service Long-Term Anadromous Fish Conservation Strategy | Questionable match (fire) and additional information needed (meadows). | L |
| NS-26 | Identify gravel starved areas in Butte Creek and implement gravel additions. Develop a spawning gravel budget and implement an augmentation plan and use flow management to optimize spawning weighted usable area in consideration of hydrologic limitations and other species (e.g., steelhead) and life stage requirements. | Spawning | Butte Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited | | L |
| NS-27 | Develop sustainable instream flow criteria for spawning and incubation periods and implement flow ramping protocols to protect all life stages of spring-run Chinook salmon. | All | Butte Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited | Identified in CVPIA Long-Term Plan. | L |
| NS-28 | Reduce the number of temporary passage impediments installed to create swimming holes in Butte Creek near Chico; conduct associated public outreach projects. | Adult Immigration | Butte Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited | | L |
| NS-29 | Identify stream reaches that have been most altered by anthropogenic factors and reconstruct a natural channel geometry scaled to current channel forming flows. | All | Butte Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited | | L |
| NS-30 | Promote or create riparian buffer strips between the Butte Creek channel and adjacent land uses. | Juvenile Emigration, Summer/Winter Rearing | Butte Creek | PG&E/CalTrout Prioritized Actions List | No reference cited | | L |
| NS-31 | Implement projects that consolidate and screen existing diversions where feasible. | All | Butte Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited | Additional information needed. | L |
| | | | | | | | |

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| Reference* Number | Description of Action | Target Life Stage(s) | Stream | Source | Reference Cited in Source | Notes | Contribution to HET (H/L) |
|---|---|---|---|---|---|---|---|
| NS-32 | Retrofit Magalia Dam on Little Butte Creek in order to provide for more storage to use for fisheries flows. | All | Little Butte Creek | HEA Steering Committee | No reference cited | An earthquake retrofit is necessary and might be an opportunity to increase storage to benefit fisheries flows. This would primarily benefit steelhead. | L |
| | | | | | | | |
| NS-34 | Construct fish ladder at upper Deer Creek falls. | Adult Immigration | Deer Creek | PG&E/CalTrout Prioritized Actions List | Spring-run chinook salmon recovery brainstorming session (11/8/05) | Habitat for spring-run limiting. | L |
| NS-79 | Provide functional fish ladder at Lower Deer Creek falls. | Adult Immigration | Deer Creek | Comment form | No reference cited | USFS supports DFG efforts to correct the ladder. | L |
| NS-35 | Acquire water from willing sellers consistent with applicable guidelines or negotiate agreements to supplement instream flows in the lower ten miles of Deer Creek to ensure passage of adult and juvenile spring-run Chinook salmon and steelhead over three diversion dams. | Adult Immigration, Juvenile Emigration | Deer Creek | PG&E/CalTrout Prioritized Actions List | AFRP Restoration Plan (USFWS 2001) | Water exchange program is being funded through the 4-Pumps mitigation program. | L |
| NS-36 | Implement water exchange agreement with the Deer Creek Irrigation Company and the Stanford-Vina Irrigation District and dedicate fish passage flows. | Adult Immigration, Adult Holding | Deer Creek | NMFS Recovery Plan Co-Manager Review Draft | http://www.delta.dfg.ca.gov/afrp/ | Check status of DCID exchange agreement. | L |
| NS-37 a | Permit and construct a state-of-the-art fish ladder that meets NMFS' adult fish passage criteria and install a new apron at the Cone-Kimball Diversion. | Adult Immigration | Deer Creek | NMFS Recovery Plan Co-Manager Review Draft | Summary of Threats and Recovery Actions for Spring-Run and Winter-Run Chinook Salmon (Notes from the Sacramento Salmon and Steelhead Recovery Workshop, May 22, 2007) | Project to improve fish passage at Stanford-Vina Dam is being considered as part of Deer Creek Floodplain Study as of Oct 2008; projects to improve fish passage at DCID and Cone-Kimball diversion dams are being discussed between Deer Creek Watershed Conservancy and irrigation districts as of Oct 2008. Identified in CVPIA Long-Term Plan. | L |
| NS-37 b | Install state-of-the-art fish ladder at Stanford-Vina Dam. | Adult Immigration | Deer Creek | NMFS Recovery Plan Co-Manager Review Draft | See NS-37 a | See NS-37 a. | L |
| NS-37 c | Design and install state-of-the-art fish passage facilities at diversions that currently do not meet the passage criteria. Study feasibility of consolidating diversion points to minimize the number of diversions on Deer Creek. Based on this study, consolidate diversions where feasible. | Adult Immigration | Deer Creek | NMFS Recovery Plan Co-Manager Review Draft | See NS-37 a | See NS-37 a. | L |
| NS-37 d | Conduct a study designed to determine adult fish passage flows at critical riffles and fish ladders; recommend and implement actions to acquire the flows indicated for passage. | Adult Immigration | Deer Creek | NMFS Recovery Plan Co-Manager Review Draft | See NS-37 a | See NS-37 a. | L |

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|---|---|---|---|---|---|---|---|
| NS-38 | Enhance watershed resiliency by identifying and implementing projects that would reduce the potential for, and magnitude of a catastrophic wildfire, restore meadows (Deer Creek meadows, Childs meadows, Gurnsey Creek, and North Fork Deer Creek) to potentially increase summer flows and reduce local water temperatures, or increase riparian shade. | All | Deer Creek | NMFS Recovery Plan Co-Manager Review Draft | Deer Creek Watershed Existing Conditions Report and U.S. Forest Service Long-Term Anadromous Fish Conservation Strategy | Questionable match (fire) and additional information needed (meadows). | L |
| NS-80 | Reduce sources of chronic road related erosion of sediment | All | Deer Creek | Comment form | No reference cited | On-going activity. | L |
| NS-40 | Build sediment retention structures; fortify streambanks with native vegetation. | Spawning, Egg Incubation | Deer Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited | Issue? | L |
| NS-41 | Identify gravel starved areas in Deer Creek and implement gravel additions. Re-design highway 32 culvert crossing at Calf Creek to allow for unimpeded bedload transport. Conduct a spawning gravel augmentation feasibility study to increase available spawning habitat. Implement spawning gravel augmentation projects if the feasibility study determines that such projects will not cause adverse ecological impacts. | Spawning | Deer Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited | Issue? HWY 32 culvert managed by CALTRANS (need to be included). | L |
| NS-44 | Implement all or portions of the Deer Creek floodplain feasibility study, which can include (1) purchasing conservation easements, (2) moderate levee setbacks on both banks between Red Bridge and Stanford Vina Ranch Irrigation Company (SVRIC) dam, (3) replace current SVRIC dam with a seasonal dam, and (4) rebuild/expand Red Bridge. | Summer/Winter Rearing | Deer Creek | PG&E/CalTrout Prioritized Actions List; Questionnaire | Collaborative Group 2006, Draft Lower Deer Creek Ecosystem Restoration and Flood Management Technical Memorandum by Mark R. Tompkins and G.M. Kondolf (2008), AFRP Restoration Plan (USFWS 2001) | The Deer Creek Watershed Conservancy completed a floodplain feasibility study. The study developed two action alternatives. | L |
| NS-45 | Identify and implement projects designed to improve downstream passage conditions for juveniles. | Juvenile Emigration | Deer Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited | | L |
| NS-46 | Identify stream reaches that have been most altered by anthropogenic factors and reconstruct a natural channel geometry scaled to current channel forming flows. | All | Deer Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited | | L |
| | | | | | | | |
| NS-47 | Design and install state of the art fish screens at diversions that currently do not meet the NMFS fish screen criteria. | Juvenile Emigration | Feather River | NMFS Recovery Plan Co-Manager Review Draft | No reference cited | | L |
| NS-90 | Implement a trap-and-haul project on the North Fork Feather River. | All | Feather River | Comment form | No reference cited | | H |
| NS-91 | Implement a trap-and-haul project on the Middle Fork Feather River. | All | Feather River | Comment form | No reference cited | | H |
| | | | | | | | |

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| Reference* Number | Description of Action | Target Life Stage(s) | Stream | Source | Reference Cited in Source | Notes | Contribution to HET (H/L) |
|---|---|---|---|---|---|---|---|
| NS-49 | Identify stream reaches that have been most altered by anthropogenic factors and reconstruct a natural channel geometry scaled to current channel forming flows. | All | Feather/Yuba Rivers | NMFS Recovery Plan Co-Manager Review Draft | No reference cited | | L |
| | | | | | | | |
| NS-51 | Purchase TNC's Mill Creek Water Rights to provide additional stream flows for spring-run Chinook and steelhead. | All | Mill Creek | PG&E/CalTrout Prioritized Actions List; Questionnaire | AFRP Restoration Plan (USFWS 2001) | Project provides 18 cfs or nearly 10% of Mill Creek base flow. Delta 4-pumps pays for pumping costs associated with Ground Water Exchange Program. TNC purchased with intent to sell. Identified in CVPIA Long-Term Plan. | L |
| NS-52 b | Conduct fish passage evaluation at all agricultural diversions to determine if they meet NMFS' fish passage criteria, and design and install state-of-the-art fish passage facilities at diversions that currently do not meet the passage criteria. | Adult Immigration | Mill Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited | | L |
| NS-81 | Reduce sources of chronic road related erosion of sediment. | All | Mill Creek | Comment form | No reference cited | On-going activity. | L |
| NS-54 | Restore meadows and reduce stream channel incisement and bank erosion by modifying grazing practices and excluding cattle from nearshore zones, and reduce the potential for, and magnitude of a catastrophic wildfire. | Spawning, Egg Incubation | Mill Creek | NMFS Recovery Plan Co-Manager Review Draft | U.S. Forest Service Long-Term Anadromous Fish Conservation Strategy | | L |
| NS-55 | Work with State and Federal water acquisition programs to develop dedicated instream water (Orange Cove water right purchase); participate in the lower Mill Creek Watershed Restoration | All | Mill Creek | NMFS Recovery Plan Co-Manager Review Draft | http://www.delta.dfg.ca.gov/afrp/ | | H |
| NS-56 | Build sediment retention structures; fortify streambanks with native vegetation. | Spawning, Egg Incubation | Mill Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited | Issue? | L |
| NS-57 | Implement projects to increase floodplain habitat availability to improve habitat conditions for juvenile rearing. | Summer/Winter Rearing | Mill Creek | NMFS Recovery Plan Co-Manager Review Draft | Summary of Threats and Recovery Actions for Spring-Run and Winter-Run Chinook Salmon (Notes from the Sacramento Salmon and Steelhead Recovery Workshop, May 22, 2007) | Issue? | L |
| NS-58 | Identify and implement projects designed to improve downstream passage conditions for juveniles. | Juvenile Emigration | Mill Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited | Issue? | L |
| NS-59 | Identify stream reaches that have been most altered by anthropogenic factors and reconstruct a natural channel geometry scaled to current channel forming flows. | All | Mill Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited | Issue? | L |
| NS-60 | Establish, restore, and maintain riparian habitat along the lower reaches of Mill Creek. | Juvenile Emigration, Summer/Winter Rearing | Mill Creek | PG&E/CalTrout Prioritized Actions List | AFRP Restoration Plan (USFWS 2001) | Issue? Past AFRP project. | L |
| | | | | | | | |

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| Reference* Number | Description of Action | Target Life Stage(s) | Stream | Source | Reference Cited in Source | Notes | Contribution to HET (H/L) |
|---|---|---|---|---|---|---|---|
| NS-63 | Construct improved fish passage facilities at Daguerre Point Dam to provide for segregation of adult spring-run and fall-run chinook salmon. | Spawning, Egg Incubation | Yuba River | PG&E/CalTrout Prioritized Actions List | Spring-run chinook salmon recovery brainstorming session (11/8/05) | It is difficult to determine how segregation would contribute to the HEA threshold. Impact to migrating steelhead is also a concern. No preferred alternative selected yet. | H |
| NS-64 | Modify the fish ladders at Daguerre Point Dam to provide full fish passage. | Adult Immigration | Yuba River | NMFS Recovery Plan Co-Manager Review Draft; Questionnaire | Daguerre Point Dam Fish Passage Improvement Project 2002 Fisheries Study | No preferred alternative selected yet. | L |
| NS-65 | Facilitate passage of juvenile salmonids by modifying the dam face of Daguerre Point Dam. | Juvenile Emigration | Yuba River | PG&E/CalTrout Prioritized Actions List | AFRP Restoration Plan (USFWS 2001) | No preferred alternative selected yet. | L |
| NS-67a | Implement actions to enhance habitat conditions and improve access within the area above Englebright Dam, including increasing minimum flows, providing passage at Our House, New Bullards Bar, and Log Cabin dams, and assessing feasibility of passage improvement at natural barriers. | All | Yuba River | NMFS Recovery Plan Co-Manager Review Draft | No reference cited | PG&E and NID are currently relicensing projects in the upper Yuba watershed; anadromous salmonid issues in the upper watershed are generally being handled outside of FERC relicensing. | H |
| NS-94 a | Implement a trap-and-haul program around Englebright Dam for the North Yuba River above New Bullards Bar Reservoir. | All | Yuba River | | No reference cited. | | H |
| NS-94 b | Implement a trap-and-haul program around Englebright Dam for the North Yuba River below New Bullards Bar Reservoir. | All | Yuba River | | No reference cited. | | H |
| NS-94 c | Implement a trap-and-haul program around Englebright Dam for the Middle Yuba River in combination with increased flow releases. | All | Yuba River | | No reference cited. | | H |
| NS-69 | Improve efficiency of screening devices at Brophy-South Yuba water diversion and other unscreened diversions. | Juvenile Emigration | Yuba River | PG&E/CalTrout Prioritized Actions List | AFRP Restoration Plan (USFWS 2001) | Required under Yuba River Accord and BO. | L |
| NS-83 | Restore backwater, side-channel, and riparian/ floodplain habitat in the Lower Yuba River. | Juvenile Emigration, Summer/Winter Rearing | Yuba River | Questionnaire | No reference cited | Project will build on current AFRP-funded pilot project and complements Narrows Gravel Rehabilitation Project (NS-86). | L |
| NS-84 a | Rehabilitate Yuba River Narrows spawning habitat. | Spawning | Yuba River | Questionnaires | SHIRA-based river analysis (Pasternack 2009) and Draft Implementation Plan for Lower Yuba River Anadromous Fish Restoration | Rehabilitates habitat and supplies 100 tons of gravel that is then maintained under the Corps requirements. Pilot project completed in 2007. Requires injection of 54,000 cubic yards of gravel. | H |
| NS-84 b | Rehabilitate Yuba River Narrows spawning habitat with possible segregation weir approximately 6 miles below Englebright Dam. | Spawning | Yuba River | Questionnaire | Draft Implementation Plan for Lower Yuba River Anadromous Fish Restoration | FWS and DFG do not currently support using a segregation weir. | H |
| | | | | | | | |
| NS-89 | Implement Deer Creek Salmon and Steelhead Spawning Habitat Expansion Project. | Spawning | Deer Creek/ Yuba River | Questionnaire | No reference cited | Restore habitat via gravel augmentation, barrier removal, invasive species removal, and riparian revegetation. Project enhances mitigation requirements. | L |
| | | | | | | | |

*Reference numbers are not necessarily in consecutive order, but actions are grouped by watershed.

| Reference* Number | Description of Action | Target Life Stage(s) | Stream | Source | Reference Cited in Source | Notes | Contribution to HET (H/L) |
|---|---|---|---|---|---|---|---|
| NS-85 | Operate and maintain real-time flow and temperature monitoring gages on Big Chico, Butte, Deer, and Mill Creeks (with possible expansion to Antelope Creek). | All | Big Chico, Butte, Deer, and Mill creeks | Questionnaire | AFRP Restoration Plan (USFWS 2001) | Funds continued operation and maintenance of flow gauges that lose funding in 2010. | L |
| | | | | | | | |
| NS-93 | Evaluate and implement fish passage upstream of Folsom Lake into the Middle Fork (and possibly North Fork) of the American River. | All | American River | Comment Form | No reference cited. | Action may be ineligible under HEA Section 3.2 because required under OCAP BO. | H |
| | | | | | | | |
| **Basalt and Porous Lava Spring-Run Chinook Salmon Diversity Group** | | | | | | | |
| B-1 | Implement Phase 1(b) of the package of passage, screening, and flow actions defined for the Battle Creek Restoration Project as defined by the Memorandum of Understanding (i.e., tailrace connector between Inskip Powerhouse and Coleman Canal on the South Fork Battle Creek). | Adult Immigration | Battle Creek | PG&E/CalTrout Prioritized Actions List | Battle Creek Restoration Plan (Kier and Associates 1999). | Action may be ineligible under HEA Section 3.2 because required under OCAP BO. Federal Stimulus Funding may also be available. | L |
| B-2 | Implement Phase 2 of the package of passage, screening, and flow actions defined for the Battle Creek Restoration project, as defined by the Memorandum of Understanding (i.e., removal of Coleman Diversion Dam, South Diversion Dam, Soap Creek Feeder, and Lower Ripley Creek Feeder; fish ladder and screen construction at Inskip Diversion Dam; tailrace connector between South Powerhouse and Inskip Canal; and streamflow increases in South Fork Battle Creek). | All | Battle Creek | PG&E/CalTrout Prioritized Actions List | Battle Creek Restoration Plan (Kier and Associates 1999). | Action may be ineligible under HEA Section 3.2 because required under OCAP BO. | H |
| B-4 | Develop and implement pulse flow schedules during peak migration periods for years with low water availability. | Adult Immigration | Battle Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited | | L |
| B-9 | Modernize/upgrade PG&E facilities to reduce the potential for flow fluctuations and outages. | All | Battle Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited | | L |
| B-12 | Develop and increase application of alternative diversion technologies that eliminate entrainment. | Juvenile Emigration | Battle Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited | | L |

*Reference numbers are not necessarily in consecutive order, but actions are grouped by watershed.

| Reference* Number | Description of Action | Target Life Stage(s) | Stream | Source | Reference Cited in Source | Notes | Contribution to HET (H/L) |
|---|---|---|---|---|---|---|---|
| B-15 | Conduct feasibility studies for allowing spring-run Chinook salmon access to habitat above Shasta Dam, including assessing habitat suitability and passage logistics (i.e., getting immigrating adults above the dam and emigrating juveniles below it). If the feasibility studies suggest that fish passage can be successful, then design and conduct an experimental fish passage program evaluating adult distribution, survival, spawning, and production in habitats above Shasta Dam.<br><br>If the experimental fish passage program demonstrates that passage above Shasta dam can substantively contribute to the long-term viability of the ESU, then develop and implement long-term fish passage programs. Implement an annual trap-and-haul operation, if warranted. | Adult Immigration, Adult Holding, Spawning | Sacramento River | NMFS Recovery Plan Co-Manager Review Draft | No reference cited. | Action may be ineligible under HEA Section 3.2 because required under OCAP BO. | H |
| | | | | | | | |
| B-18 | Conduct periodic (e.g., every 5 years) spawning gravel assessments in the upper Sacramento River (i.e., above RBDD) and implement gravel augmentation projects, as necessary. | Spawning | Sacramento River | NMFS Recovery Plan Co-Manager Review Draft | No reference cited | Benefits steelhead but not spring-run. | L |
| | | | | | | | |
| B-19 | Modify gravel pits and mounds to ensure full drainage of these features to allow flooding while preventing stranding and warm water predator habitat. | Juvenile Emigration, Summer/Winter Rearing | Upper Sacramento River | NMFS Recovery Plan Co-Manager Review Draft | No reference cited | The Recovery Plan mentions this action in reference to the juveniles produced in the Sacramento River. La Barranca floodplain project needs funding for construction. | L |
| B-20 | Restore the current Lake Red Bluff footprint to riparian habitat. | All | Upper Sacramento River | NMFS Recovery Plan Co-Manager Review Draft | No reference cited | | L |
| **Northwestern California Spring-Run Chinook Salmon Diversity Group** | | | | | | | |
| NWC-1 | Enhance watershed resiliency by identifying and implementing projects that would reduce the potential for, and magnitude of a catastrophic wildfire, restore meadows to potentially increase summer flows and reduce local water temperatures, or increase riparian shade. | All | Beegum Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited | Issue? | L |
| NWC-2 | Develop and implement a spawning gravel augmentation plan. | Spawning | Beegum Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited | Issue? | L |
| NWC-3 | Eliminate sources of chronic sediment delivery from roads and other near stream development by out-sloping roads, constructing diversion prevention dips, replacing under-sized culverts and applying other storm proofing guidelines. | Spawning, Egg Incubation | Beegum Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited | | L |
| | | | | | | | |
| NWC-5 | Inject LWD and boulders in the canyon reach of Clear Creek to induce gravel deposition to support pocket spawning by salmonids. | Spawning | Clear Creek | PG&E/CalTrout Prioritized Actions List | Collaborative Group 2006 | Issue w/ kayakers, lower priority | L |

*Reference numbers are not necessarily in consecutive order, but actions are grouped by watershed.

| Reference* Number | Description of Action | Target Life Stage(s) | Stream | Source | Reference Cited in Source | Notes | Contribution to HET (H/L) |
|---|---|---|---|---|---|---|---|
| NWC-6 | Clear Creek gravel supplementation in the reach where spring-run Chinook and steelhead spawn by placing gravel directly into four new sites and supplementing existing sites with "injected" gravel. | Spawning | Clear Creek | Questionnaires | Graham Matthews and Associates 2007, North State Resources 2008, and additional references provided in Questionnaire | This would not be self-sustaining. It would need to be redone periodically but works synergistically with NWC-8 and NWC-20. Potential/perfect substrate estimated to support 5,264 spring-run and 12,816 steelhead. Gravel augmentation required under OCAP BO. | H |
| NWC-25 | Developing long-term spawning gravel supply by processing gold mine tailings on DFG and BLM properties adjacent to Clear Creek. | Spawning | Clear Creek | Questionnaire | North State Resources 2008 and additional references provided in Questionnaire | Provides Long-Term and inexpensive supply of spawning gravel, prevents entrainment of mercury, and creates functional floodplain in tailing area. CVPIA funded and completed feasibility study. Gravel augmentation required under OCAP BO. | L |
| NWC-9 | Enhance watershed resiliency by identifying and implementing projects that would reduce the potential for, and magnitude of a catastrophic wildfire, restore meadows to potentially increase summer flows and reduce local water temperatures, or increase riparian shade. | All | Clear Creek | NMFS Recovery Plan Co-Manager Review Draft | Summary of Threats and Recovery Actions for Spring-Run and Winter-Run Chinook Salmon (Notes from the Sacramento Salmon and Steelhead Recovery Workshop, May 22, 2007) | Include only wildlife and revegetation actions (lower priority) since other issues being implemented. | L |
| NWC-10 | Conduct a passage feasibility study, including an assessment of potential habitat above Whiskeytown Dam. If the action is feasible and passage above Whiskeytown Dam can substantively contribute to the Long-Term viability of the ESU, then develop and implement a Long-Term fish passage program. | Adult Immigration, Adult Holding, Spawning | Clear Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited | Feasibility concerns due to flow, mine contamination, upstream passage barriers, gravel availability, and trap-and-haul limitations | H |
| NWC-13 | Eliminate sources of chronic sediment delivery from roads and other near stream development by out-sloping roads, constructing diversion prevention dips, replacing under-sized culverts and applying other storm proofing guidelines. | Spawning, Egg Incubation | Clear Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited | Lower priority since most feasible projects already completed. Parks is pursing funding for inventory. | L |
| | | | | | | | |
| NWC-18 a | Protect/enhance existing riparian habitat and corridors and establish and restore additional riparian habitat where needed. | Juvenile Emigration, Summer/Winter Rearing | Cottonwood Creek | NMFS Recovery Plan Co-Manager Review Draft | Summary of Threats and Recovery Actions for Spring-Run and Winter-Run Chinook Salmon (Notes from the Sacramento Salmon and Steelhead Recovery Workshop, May 22, 2007) | This action, while on Cottonwood Creek, is mentioned in the Recovery Plan as benefiting Beegum Creek. Some AFRP projects are in place. | L |
| NWC-18 b | Implement non-native plant (e.g. Arundo) eradication plan. | Juvenile Emigration, Summer/Winter Rearing | Cottonwood Creek | NMFS Recovery Plan Co-Manager Review Draft | See NWC-18 a. | See NWC-18 a. | L |
| NWC-19 | Re-establish natural channel morphology by: (1) applying NMFS gravel mining criteria to all gravel mining projects; and (2) integrating natural morphological features and functions into bank protection and other stream side development projects. | All | Cottonwood Creek | NMFS Recovery Plan Co-Manager Review Draft | No reference cited | This action, while on Cottonwood Creek, is mentioned in the Recovery Plan as benefiting Beegum Creek. AFRP needs funding for sediment budget study. | L |

*Reference numbers are not necessarily in consecutive order, but actions are grouped by watershed.

| Reference* Number | Description of Action | Target Life Stage(s) | Stream | Source | Reference Cited in Source | Notes | Contribution to HET (H/L) |
|---|---|---|---|---|---|---|---|
| **Sacramento River Basinwide** | | | | | | | |
| SBW-1 a | Implement bank revetment removal programs and projects and breach or remove abandoned levees during set-back levee projects. | Juvenile Emigration, Summer/Winter Rearing | Upper and Middle Sacramento River | NMFS Recovery Plan Co-Manager Review Draft | http://www.nature.org/wherewework/northamerica/states/california/ | Worth considering after assessing current carrying capacity of Sacramento River mainstem habitats. | L |
| SBW-1 b | Restore a continuous 100-mile stretch of ecologically viable riparian habitat to flood-prone lands along the river between Red Bluff and Colusa. | Juvenile Emigration, Summer/Winter Rearing | Upper and Middle Sacramento River | NMFS Recovery Plan Co-Manager Review Draft | http://www.nature.org/wherewework/northamerica/states/california/ | Worth considering after assessing current carrying capacity of Sacramento River mainstem habitats. | L |
| SBW-3 a | Promote native riparian (e.g., willows) species through eradication of non-native species (e.g., Arundo, tamarisk). | Juvenile Emigration, Summer/Winter Rearing | Lower Sacramento River | NMFS Recovery Plan Co-Manager Review Draft | No reference cited | Worth considering after assessing current carrying capacity of Sacramento River mainstem habitats. | L |
| SBW-3 b | Modify vegetation maintenance practices to encourage riparian growth and establish a native vegetated corridor in currently unvegetated/leveed reaches of the lower Sacramento River especially between Colusa and Verona. | Juvenile Emigration, Summer/Winter Rearing | Lower Sacramento River | NMFS Recovery Plan Co-Manager Review Draft | No reference cited | See SBW-3 a. | L |
| SBW-3 c | Restore a continuous 85-mile stretch of riparian habitat of an appropriate width to maintain ecologically viable function to flood-prone lands along both banks of the river between Colusa and Sacramento. | Juvenile Emigration, Summer/Winter Rearing | Lower Sacramento River | NMFS Recovery Plan Co-Manager Review Draft | No reference cited | See SBW-3 a. May potentially be addressed under OCAP BO. | L |
| SBW-4 a | Modify vegetation maintenance practices to encourage riparian growth and establish a native vegetated corridor in currently unvegetated/leveed reaches of the middle Sacramento River. | Juvenile Emigration, Summer/Winter Rearing | Middle Sacramento River | NMFS Recovery Plan Co-Manager Review Draft | http://www.nature.org/wherewework/northamerica/states/california/ | Worth considering after assessing current carrying capacity of Sacramento River mainstem habitats. | L |
| SBW-4 b | Create and restore side-channel habitats to increase the quantity and quality of off-channel rearing (and spawning) areas. | Juvenile Emigration, Summer/Winter Rearing | Middle Sacramento River | NMFS Recovery Plan Co-Manager Review Draft | http://www.nature.org/wherewework/northamerica/states/california/ | Worth considering after assessing current carrying capacity of Sacramento River mainstem habitats. | L |
| SBW-7 | Implement projects that consolidate and screen existing diversions where feasible. | Juvenile Emigration | Sacramento River | NMFS Recovery Plan Co-Manager Review Draft | No reference cited | May potentially be addressed under OCAP BO. | L |
| SBW-11 | Develop and increase application of alternative diversion technologies that eliminate entrainment. | Juvenile Emigration | Sacramento River | NMFS Recovery Plan Co-Manager Review Draft | No reference cited | Worth considering after assessing current carrying capacity of Sacramento River mainstem habitats. | L |
| SBW-14 | Implement projects that acquire strategic floodplain easements to re-establish floodplain connectivity in areas constricted by levees. | Summer/Winter Rearing | Sacramento River | NMFS Recovery Plan Co-Manager Review Draft | No reference cited | The Recovery Plan mentions this action in reference to the juveniles produced in the Sacramento River. Worth considering after assessing current carrying capacity of Sacramento River mainstem habitat. | L |

*Reference numbers are not necessarily in consecutive order, but actions are grouped by watershed.

| Reference* Number | Description of Action | Target Life Stage(s) | Stream | Source | Reference Cited in Source | Notes | Contribution to HET (H/L) |
|---|---|---|---|---|---|---|---|
| SBW-18 | Pursue opportunities, consistent with efforts conducted pursuant to Senate Bill 1086 (SB 1086), to create a 50,000-acre meander belt from Keswick Dam to Colusa to recruit gravel and large woody debris, to moderate temperatures and to enhance nutrient input. | All | Upper /Middle Sacramento River | PG&E/CalTrout Prioritized Actions List | AFRP Restoration Plan (USFWS 2001) | Worth considering after assessing current carrying capacity of Sacramento River mainstem habitats. | L |
| SBW-19 | Operate segregation weir at ACID to separate fall-run and spring-run on mainstem. | Spawning | Upper Sacramento River | Comment form | No reference cited | DFG previously stated that they would not support this type of action. | H |

*Reference numbers are not necessarily in consecutive order, but actions are grouped by watershed.

Appendix C3

# Short List of Potential Actions

## Short List of Potential Actions

| Reference Number | Description of Action | Deal Killer (No/ Maybe) | Estimated HET Contribution | Reference for Estimated HET Contribution |
|---|---|---|---|---|
| NS-14 | Iron Canyon Fish Ladder Rehabilitation Project in Big Chico Creek. | No | 1,000 | DFG - Historical |
| NS-35, NS-37a, NS-37b, NS-95, NS-44 | Supplement flows, passage at DCID, Cone-Kimball, and Stanford-Vina Diversions, Floodplain Project in lower Deer Creek. | No | 1,000 | DFG - Historical and GRANDTAB |
| NS-5, NS-1, NS-77, NS-3, NS-10 | Paynes Crossing, supplement flow, Valley Floor Channel Project, modify ag diversion to provide passage and reduce entrainment in Antelope Creek. | No | >= 500 | DFG - Historical |
| NS-55 | Develop dedicated instream water (Orange Cove water right purchase) in Mill Creek; lower Mill Creek Watershed Restoration Project. | No | 1,900 | Questionnarie |
| NS-64, NS-65, NS-84b, NS-83, NS-89 | Adult & juvenile passage at Daguerre Point Dam, Yuba River Narrows spawning habitat w/ segregation weir, backwater, side-channel, and riparian/floodplain habitat, Deer Creek Habitat Expansion Project in the lower Yuba River. | Maybe | >= 2000 | Questionnarie |
| NS-67b | Fish Passage into Upper Yuba Watershed. | Maybe | 500 (Middle Yuba) | UYRSP Team 2006 |
| NS-84 b | Rehabilitate Yuba River Narrows spawning habitat with segregation weir in the lower Yuba River. | Maybe | >= 2000 | Questionnarie |
| NS-90 | Trap-and-haul project on the North Fork Feather River. | Maybe | 500-2500 | Payne & Associates 2004 (FERC) |
| NS-91 | Trap-and-haul project on the Middle Fork Feather River. | Maybe | < 500 below natural barrier; unknown above | DWR 2007 (FERC Report) |
| NS-93 | Trap-and-haul program on the Middle Fork (and possibly North Fork) of the American River. | Maybe | Unknown | |
| NS-94 a | Trap-and-haul program on the North Yuba River above New Bullards Bar Reservoir with habitat restoration. | Maybe | Unknown | |
| NS-94 b | Trap-and-haul program on the North Yuba River below New Bullards Bar with habitat restoration. | Maybe | Unknown | |
| NS-94 c | Trap-and-haul program on the Middle Yuba River in combination with increased flow releases and habitat restoration. | Maybe | >= 500 | UYRSP Team 2006 |
| B-2 | Phase 2 of the Battle Creek Restoration project. | Maybe | 1250-2500 | Kier & Associates 1999 |
| B-15 | Trap-and-haul program on the Sacramento River at Shasta Dam. | Maybe | Unknown | |

| | | | | |
|---|---|---|---|---|
| NWC-10 | Trap-and-haul program in Clear Creek at Whiskeytown Dam. | Maybe | Unknown | |
| NWC-6, NWC-25 | Clear Creek gravel supplementation, processing tailings and restoring floodplain habitat. | Maybe | 5,264 | Questionnarie |
| SBW-19 | Segregation weir in the Sacramento River at the Anderson-Cottonwood Irrigation District (ACID) Dam . | Maybe | 7,500 | Cramer Fish Sciences |

Appendix C4

# Ranked Preliminary List of Viable Actions with Evaluation Criteria Scoring

## Ranked Preliminary List of Viable Actions

| | | | | | EVALUATION CRITERIA | | | | | | | | | | | | | | | | | Summary | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Reference Number** | **Description of Action** | **Deal Killer (No/ Maybe)** | **Estimated HET Contribution** | **Reference for Estimated HET Contribution** | **(a)** Feasibility Score | **(b)** Scale Score | **(c)** Sustainability Score | **(d)** Cost Effective Score | **(e)** Minimal Intervention Score | **(f)** Separation-Genetic Score | **(g)** Separation-Catastrophe Score | **(h)** Time to Implement Score | **(i)** Local/ Political Support Score | **(j)** VSP/ESA Consistency Score | **(k)** Balance of Benefits Score | **(l)** Resource Consistency Score | **(m)** Available Stocks Score | **(n)** Action Taken by Others Score | **(o)** Other FR Species Score | **(p)** Adverse Effects-spp Score | **(q)** Adverse Effects-cult. Score | **Total Score** | **Norm. Total (100)** |
| B-2 | Phase 2 of the Battle Creek Restoration Project. | Maybe | 1,250-2,500 | Kier & Associates 1999 | 5 | 5 | 4 | 4 | 4 | 5 | 4 | 4 | 4 | 5 | 5 | 4 | 4 | 2 | 4 | 5 | 5 | 73 | 100.00 |
| NS-64, NS-65, NS-84b, NS-83, NS-89 | Adult & juvenile passage at Daguerre Point Dam, Yuba River Narrows spawning habitat w/ segregation weir, backwater, side-channel, and riparian/floodplain habitat, Deer Creek Habitat Expansion Project in the lower Yuba River. | Maybe | >= 2,000 | Questionnarie | 5 | 5 | 4 | 4 | 4 | 5 | 5 | 3 | 3 | 5 | 4 | 4 | 4 | 4 | 3 | 5 | 5 | 72 | 98.63 |
| NS-5, NS-1, NS-77, NS-3, NS-10 | Paynes Crossing, supplement flow, Valley Floor Channel Project, modify ag diversion to provide passage and reduce entrainment in Antelope Creek. | No | >= 500 | DFG - Historical | 5 | 4 | 4 | 4 | 4 | 4 | 2 | 3 | 5 | 4 | 5 | 5 | 4 | 4 | 4 | 5 | 4 | 70 | 95.89 |
| NS-84 b | Rehabilitate Yuba River Narrows spawning habitat with segregation weir in the lower Yuba River. | Maybe | >= 2,000 | Questionnarie | 5 | 4 | 3 | 4 | 3 | 5 | 5 | 4 | 3 | 4 | 4 | 4 | 4 | 4 | 3 | 5 | 5 | 69 | 94.52 |
| NS-14 | Iron Canyon Fish Ladder Rehabilitation Project in Big Chico Creek. | No | 1,000 | DFG - Historical | 5 | 4 | 4 | 5 | 4 | 4 | 2 | 5 | 5 | 3 | 4 | 5 | 4 | 2 | 2 | 5 | 5 | 68 | 93.15 |
| NWC-6, NWC-25 | Clear Creek gravel supplementation, processing tailings and restoring floodplain habitat. | Maybe | 5,264 | Questionnarie | 5 | 4 | 3 | 4 | 2 | 4 | 5 | 4 | 4 | 4 | 4 | 5 | 4 | 3 | 3 | 4 | 5 | 67 | 91.78 |
| NS-55 | Develop dedicated instream water (Orange Cove water right purchase) in Mill Creek; lower Mill Creek Watershed Restoration Project. | No | 1,900 | Questionnarie | 5 | 3 | 3 | 3 | 4 | 3 | 1 | 4 | 4 | 3 | 4 | 4 | 5 | 3 | 4 | 4 | 5 | 62 | 84.93 |
| NS-35, NS-37a, NS-37b, NS-95, NS-44 | Supplement flows, passage at Deer Creek Irrigation District, Cone-Kimball, and Stanford-Vina Diversions, Floodplain Project in lower Deer Creek. | No | 1,000 | DFG - Historical and GRANDTAB | 5 | 3 | 4 | 3 | 4 | 3 | 1 | 3 | 4 | 3 | 4 | 4 | 5 | 3 | 4 | 4 | 5 | 62 | 84.93 |
| SBW-19 | Segregation weir in the Sacramento River at the Anderson-Cottonwood Irrigation District (ACID) Dam . | Maybe | 7,500 | Cramer Fish Sciences | 5 | 3 | 3 | 4 | 3 | 5 | 4 | 3 | 2 | 3 | 4 | 4 | 4 | 5 | 1 | 4 | 5 | 62 | 84.93 |
| NS-90 | Trap-and-haul project on the North Fork Feather River. | Maybe | 500-2,500 | Payne & Associates 2004 (FERC) | 3 | 4 | 2 | 1 | 1 | 5 | 5 | 2 | 2 | 4 | 5 | 3 | 4 | 5 | 1 | 4 | 5 | 56 | 76.71 |
| NS-94 a | Trap-and-haul program on the North Yuba River above New Bullards Bar Reservoir with habitat restoration. | Maybe | Unknown | | 2 | 4 | 2 | 1 | 1 | 5 | 5 | 2 | 3 | 4 | 5 | 3 | 4 | 4 | 1 | 4 | 5 | 55 | 75.34 |

| | | | | | EVALUATION CRITERIA | | | | | | | | | | | | | | | | | Summary | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Reference Number** | **Description of Action** | **Deal Killer (No/ Maybe)** | **Estimated HET Contribution** | **Reference for Estimated HET Contribution** | **(a)** Feasibility Score | **(b)** Scale Score | **(c)** Sustainability Score | **(d)** Cost Effective Score | **(e)** Minimal Intervention Score | **(f)** Separation-Genetic Score | **(g)** Separation-Catastrophe Score | **(h)** Time to Implement Score | **(i)** Local/ Political Support Score | **(j)** VSP/ESA Consistency Score | **(k)** Balance of Benefits Score | **(l)** Resource Consistency Score | **(m)** Available Stocks Score | **(n)** Action Taken by Others Score | **(o)** Other FR Species Score | **(p)** Adverse Effects-spp Score | **(q)** Adverse Effects-cult. Score | **Total Score** | **Norm. Total (100)** |
| NS-91 | Trap-and-haul project on the Middle Fork Feather River. | Maybe | < 500 below natural barrier; unknown above | DWR 2007 (FERC Report) | 2 | 3 | 2 | 1 | 1 | 5 | 5 | 2 | 2 | 4 | 5 | 3 | 4 | 5 | 1 | 4 | 5 | 54 | 73.97 |
| NS-94 c | Trap-and-haul program on the Middle Yuba River in combination with increased flow releases and habitat restoration. | Maybe | >= 500 | UYRSP Team 2006 | 2 | 3 | 2 | 1 | 1 | 5 | 5 | 2 | 3 | 4 | 5 | 3 | 4 | 4 | 1 | 4 | 5 | 54 | 73.97 |
| B-15 | Trap-and-haul program on the Sacramento River at Shasta Dam. | Maybe | Unknown | | 2 | 4 | 2 | 1 | 1 | 5 | 5 | 2 | 3 | 4 | 5 | 3 | 4 | 2 | 1 | 5 | 4 | 53 | 72.60 |
| NWC-10 | Trap-and-haul program in Clear Creek at Whiskeytown Dam. | Maybe | Unknown | | 2 | 2 | 2 | 1 | 1 | 5 | 5 | 2 | 2 | 4 | 5 | 3 | 4 | 5 | 1 | 4 | 4 | 52 | 71.23 |
| NS-94 b | Trap-and-haul program on the North Yuba River below New Bullards Bar with habitat restoration. | Maybe | Unknown | | 2 | 2 | 2 | 1 | 1 | 5 | 5 | 2 | 3 | 3 | 5 | 3 | 4 | 4 | 1 | 4 | 5 | 52 | 71.23 |
| NS-93 | Trap-and-haul program on the Middle Fork (and possibly North Fork) of the American River. | Maybe | Unknown | | 2 | 4 | 2 | 1 | 1 | 5 | 5 | 2 | 3 | 4 | 5 | 3 | 1 | 2 | 1 | 4 | 5 | 50 | 68.49 |

Appendix C5

# Ranked List of Viable Actions with Selection Criteria Scoring

## Ranked List of Viable Actions with Selection Criteria Evaluation

| | | | | **(a)** Contribution | **(b)** Cost Effective | **(c)** Feasibility | **(d)** Time to Implement | Selection Criteria | Evaluation Criteria | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Reference Number** | **Description of Action** | **Estimated HET Contribution[a]** | **Estimated Cost (incl. O&M)[b]** | **Score** | **Score** | **Score** | **Score** | **Score** | **Weighted Score** | **Product** | **Norm Prod** |
| NS-5 | Paynes Crossing in Antelope Creek. | ~250 | 1.0M | 1 | 5 | 5 | 5 | 16 | 0.96 | 15.36 | 100.0 |
| NS-84 b | Rehabilitate Yuba River Narrows spawning habitat with segregation weir in the lower Yuba River. | ~3,250 | 16M | 3 | 5 | 4 | 4 | 16 | 0.94 | 15.04 | 97.9 |
| NS-14 | Iron Canyon Fish Ladder Rehabilitation Project in Big Chico Creek. | ~500 | 2.7M | 1 | 5 | 5 | 5 | 16 | 0.93 | 14.88 | 96.9 |
| NS-84b, NS-83, NS-89 | Yuba River Narrows spawning habitat w/ segregation weir, backwater, side-channel, and riparian/floodplain habitat, Deer Creek Habitat Expansion Project in the lower Yuba River. | ~3,450 | 20.6M | 3 | 5 | 4 | 3 | 15 | 0.99 | 14.85 | 96.7 |
| B-2 | Phase 2 of the Battle Creek Restoration Project. | ~1600 | 46.3M | 1 | 3 | 4 | 4 | 12 | 1 | 12 | 78.1 |
| NS-5, NS-1,NS-77, NS-3, NS-10 | Paynes Crossing; supplement flow; Valley Floor Channel[c]; modify ag diversions to provide passage and reduce entrainment in Antelope Creek. | ~350 | 8.0M | 1 | 3 | 5 | 3 | 12 | 0.96 | 11.52 | 75.0 |
| NS-55 | Develop dedicated instream water (purchase The Nature Conservancy water rights, Orange Cove water right, & water from other willing sellers) in Mill Creek. | < 100 | 3.0M | 1 | 3 | 4 | 4 | 12 | 0.85 | 10.2 | 66.4 |

| | | | | **(a)** Contribution | **(b)** Cost Effective | **(c)** Feasibility | **(d)** Time to Implement | Selection Criteria | Evaluation Criteria | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Reference Number** | **Description of Action** | **Estimated HET Contribution[a]** | **Estimated Cost (incl. O&M)[b]** | **Score** | **Score** | **Score** | **Score** | **Score** | **Weighted Score** | **Product** | **Norm Prod** |
| NS-35, NS-37a, NS-37b, NS-44 | Supplement flows in Deer Creek; improve passage at Stanford-Vina, Cone-Kimball and Deer Creek Irrigation District diversion dams; implement Floodplain Project in lower Deer Creek. | ~600 | 32.3M | 1 | 3 | 4 | 3 | 11 | 0.85 | 9.35 | 60.9 |
| NS-94 a | Trap-and-haul program on the North Yuba River above New Bullards Bar Reservoir with habitat restoration. | ~1,750[d] | [100M] | 1 | 3 | 2 | 2 | 8 | 0.75 | 6 | 39.1 |
| NS-94 c | Trap-and-haul program on the Middle Yuba River in combination with increased flow releases and habitat restoration. | ~500[d] | [75M] | 1 | 1 | 2 | 2 | 6 | 0.74 | 4.44 | 28.9 |
| NS-94 b | Trap-and-haul program on the North Yuba River below New Bullards Bar with habitat restoration. | [500] | [75M] | 1 | 1 | 2 | 2 | 6 | 0.71 | 4.26 | 27.7 |

[a]Contribution from Quantification Method (unless noted otherwise).
[b]O&M costs calculated for 50-year term.
[c]Valley Floor Channel implementation costs based on estimates from the Lower Clear Creek Restoration Project.
[d]Contribution for North Fork estimated from Ripple; Middle Fork estimated from Upper Yuba River Studies Program
Note: brackets indicate unsubstantiated estimate.

Appendix D

# Central Valley Spring-run Chinook Salmon and Steelhead in the Sacramento River Basin Background Report

STATE OF CALIFORNIA
THE NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF ENVIRONMENTAL SERVICES

# CENTRAL VALLEY SPRING-RUN CHINOOK SALMON AND STEELHEAD IN THE SACRAMENTO RIVER BASIN BACKGROUND REPORT

**November 2009**


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## Table of Contents

**Introduction** ..... **1**

**Central Valley Spring-Run Chinook Salmon** ..... **1**

Listing Status ..... 1

General Life History ..... 2

Historical Distribution ..... 2

Current Distribution ..... 5

Population Viability Assessment ..... 5

**Central Valley Steelhead** ..... **8**

Listing Status ..... 8

General Life History ..... 8

Historical Distribution ..... 9

Current Distribution ..... 9

Population Viability Assessment ..... 10

**Restoration Activities in the Sacramento River Basin** ..... **10**

Central Valley Project Improvement Act ..... 10

CALFED ..... 11

Sacramento River Basin Tributaries: Status of Spring-Run Chinook Salmon and Steelhead ..... 11

**Clear Creek** ..... **14**

Spawning/Holding Habitat ..... 14

Rearing Habitat ..... 15

Monitoring Activities ..... 15

Limiting Factors ..... 15

Restoration Activities ..... 16

**Cow Creek** ..... **16**

Spawning/ Holding Habitat ..... 16

Rearing Habitat ..... 17

Monitoring Activities ..... 17

Limiting Factors ..... 17

Restoration Activities ..... 17

**Bear Creek** ..... **18**

Spawning/ Holding Habitat ..... 18

Rearing Habitat ..... 18

Limiting Factors ..... 19

Monitoring Activities ..... 19

Restoration Activities ..... 19

**Cottonwood/Beegum Creeks ..... 19**

Spawning/ Holding Habitat ..... 19

Rearing Habitat ..... 20

Limiting Factors ..... 20

Monitoring Activities ..... 20

Restoration Activities ..... 20

**Battle Creek ..... 21**

Spawning/ Holding Habitat ..... 21

Rearing Habitat ..... 22

Limiting Factors ..... 22

Monitoring Activities ..... 22

Restoration Activities ..... 22

**Thomes Creek ..... 23**

Spawning/ Holding Habitat ..... 23

Rearing Habitat ..... 23

Limiting Factors ..... 24

Monitoring Activities ..... 24

Restoration Activities ..... 24

**Stony Creek ..... 24**

Spawning/ Holding Habitat ..... 24

Rearing Habitat ..... 24

Limiting Factors ..... 25

Monitoring Activities ..... 25

Restoration Activities ..... 25

**Antelope Creek ..... 25**

Spawning/ Holding Habitat ..... 25

Rearing Habitat ..... 26

Limiting Factors ..... 26

Monitoring Activities ..... 26

Restoration Activities ..... 26

**Mill Creek ..... 27**

Spawning/ Holding Habitat ..... 27

Rearing Habitat ..... 27

Limiting Factors ..... 28

Monitoring Activities ..... 28

Restoration Activities ..... 28

**Deer Creek ..... 29**

Spawning/ Holding Habitat ..... 29

Rearing Habitat ..... 30

Limiting Factors ..... 30

Monitoring Activities ..... 30

Restoration Activities ..... 30

**Butte Creek ..... 32**

Spawning/ Holding Habitat ..... 32

Rearing Habitat ..... 33

Limiting Factors ..... 33

Monitoring Activities ..... 33

Restoration Activities ..... 33

**Big Chico Creek ..... 35**

Spawning/ Holding Habitat ..... 35

Rearing Habitat ..... 36

Limiting Factors ..... 36

Monitoring Activities ..... 36

Restoration Activities ..... 36

**Yuba River ..... 37**

Spawning/ Holding Habitat ..... 37

Rearing Habitat ..... 38

Limiting Factors ..... 38

Monitoring Activities ..... 38

Restoration Activities ..... 39

**American River ..... 40**

Spawning/ Holding Habitat ..... 40

Rearing Habitat ..... 41

Limiting Factors ..... 41

Monitoring Activities ..... 41

Restoration Activities ..... 42

**References ..... 43**

Literature Cited ..... 43

Other Sources ..... 50

## List of Acronyms

| | |
|---|---|
| AFRP | Anadromous Fish Restoration Program |
| AROG | American River Operations Work Group |
| BCWC | Butte Creek Watershed Conservancy |
| CCWG | Cottonwood Creek Watershed Group |
| CCWMP | Cow Creek Watershed Management Program |
| CDFG | California Department of Fish and Game |
| CNFH | Coleman National Fish Hatchery |
| CSU | California State University |
| CVP | Central Valley Project |
| CVPIA | Central Valley Project Improvement Act |
| DCID | Deer Creek Irrigation District |
| DCWC | Deer Creek Watershed Conservancy |
| Delta | Sacramento-San Joaquin Delta |
| DIDSON | dual-frequency identification sonar |
| DWR | California Department of Water Resources |
| ERP | Ecosystem Restoration Program |
| ESA | federal Endangered Species Act |
| ESU | environmentally significant unit |
| EWP | Environmental Water Program |
| FERC | Federal Energy Regulatory Commission |
| FERC Project 2100 | Pacific Gas and Electric Company's Oroville Facilities Project |
| FERC Project 2105 | Pacific Gas and Electric Company's Upper North Fork Feather River Project |
| FERC Project 2107 | Pacific Gas and Electric Company's Poe Project |
| FISH | Fisheries and Instream Habitat |
| Forest Service | U. S. Department of Agriculture Forest Service |
| GCID | Glenn-Colusa Irrigation District |
| GIS | geographic information systems |

| | |
|---|---|
| HEA | Habitat Expansion Agreement |
| IFIM | instream flow incremental methodology |
| km | kilometer(s) |
| LMMWC | Los Molinos Mutual Water Company |
| MOU | Memorandum of Understanding |
| NMFS | U. S. Department of Commerce, National Marine Fisheries Service |
| PG&E | Pacific Gas and Electric Company |
| PVA | population viability assessment |
| RCMP | River Corridor Management Plan |
| Reclamation | U. S. Bureau of Reclamation |
| Restoration Project | Battle Creek Salmon and Steelhead Restoration Project |
| RM | River Mile |
| State Water Board | California State Water Resources Control Board |
| Study Team | Upper Yuba River Studies Program Study Team |
| SVRIC | Stanford-Vina Ranch Irrigation Company |
| USACE | U. S. Army Corps of Engineers |
| USFWS | U. S. Fish and Wildlife Service |
| VSP | viable salmonid population |
| WUA | weighted usable area |
| YOY | young of the year |
| Yuba Accord | Lower Yuba River Accord |

# Central Valley Spring-Run Chinook Salmon and Steelhead in the Sacramento River Basin Background Report

# Introduction

Effective November 20, 2007, Pacific Gas and Electric Company (PG&E) and the California Department of Water Resources (DWR) entered into the Habitat Expansion Agreement (HEA) with the following parties: American Rivers, Arthur G. Baggett, Jr. (signing as a recommendation to the California State Water Resources Control Board [State Water Board]), California Department of Fish and Game (CDFG), U.S. Department of Agriculture Forest Service (Forest Service), U.S. Department of Commerce National Marine Fisheries Service (NMFS), U.S. Fish and Wildlife Service (USFWS), and State Water Contractors, Inc. Under the agreement, PG&E and DWR have 2 years to jointly identify, evaluate, and select the most promising and cost-effective action(s) to expand spawning, rearing, and adult holding habitat for spring-run Chinook salmon and steelhead in the Sacramento River basin, as an alternative to the Resource Agencies and other parties seeking project-specific fish passage prescriptions or license conditions in the New Project Licenses for PG&E's Upper North Fork Feather River Project (Federal Energy Regulatory Commission [FERC] Project No. 2105) and Poe Project (FERC Project No. 2107) and DWR's Oroville Facilities Project (FERC Project No. 2100).

The purpose of this *Central Valley Spring-Run Chinook Salmon and Steelhead in the Sacramento River Basin Background Report* (Background Report) is to provide background information on the status of spring-run Chinook salmon and Central Valley steelhead populations throughout watersheds in the Sacramento River basin. The information synthesized in the report will be used to support PG&E and DWR in identifying, evaluating, and selecting potential habitat expansion actions, to fulfill their obligations under the HEA.

# Central Valley Spring-Run Chinook Salmon

## Listing Status

In 1999, NMFS listed the Central Valley spring-run Chinook salmon evolutionarily significant unit (ESU) as threatened under the federal Endangered Species Act (ESA) (NMFS 1999). The Central Valley ESU includes all naturally spawned populations in the Sacramento River, tributaries of the Sacramento River, and the Feather River (DWR 2007). In 2005, NMFS published a final listing determination for Central Valley spring-run that added Feather River Hatchery spring-run to the designation (DWR 2007). In 2005, NMFS published the final designation of critical habitat, which includes the Sacramento, lower Feather, and Yuba Rivers; and Beegum, Battle, Clear, Cottonwood, Antelope, Mill, Deer, Butte, and Big Chico Creeks (DWR 2007).

# General Life History

Central Valley spring-run Chinook salmon generally leave the ocean and enter the Sacramento River from March to July as immature fish. Once they arrive at the spawning grounds, spring-run adults mature over the summer and spawn between late August and early October (NMFS 2002). Historically, spring-run adults ascended to higher elevation reaches to avoid excessive summer temperatures during this holding period (Healey 1991). Spring-run Chinook spawn in gravel beds located at the tails of holding pools (USFWS 1995). The eggs are deposited in the gravel, where incubation, hatching, and emergence occur.

The emergence of spring-run fry occurs from November to March, depending on water temperatures (CDFG 1998). Central Valley spring-run Chinook exhibit both of the freshwater life history types described by Healey (1991). The *stream-type* Chinook reside in freshwater for a year or more following emergence, and the *ocean-type* Chinook salmon migrate to the ocean within their first year. The fry use shallow, nearshore areas with slow current and good cover (CDFG 1998).

Higher elevation streams such as Mill and Deer Creeks generally have a higher proportion of spring-run exhibiting the stream-type life history. The proportion varies annually depending on stream conditions (Harvey-Arrison pers. comm.). These juveniles spend 9 to 10 months in their natal streams and up to 18 months in freshwater (USFWS 1995, CDFG 1998). In lower elevation streams such as Butte Creek, the juveniles exhibit more of an ocean-type life history with a higher proportion of the production leaving the tributaries from December to February (CDFG 2000). These young-of-the-year (YOY) Chinook may rear in the bypasses, the lower Sacramento River, and the Sacramento-San Joaquin River Delta (Delta) until ready to enter the ocean. CDFG conducted a life history investigation on Butte Creek from 1995 to 2003 and found that spring-run that emigrated from the creek as yearlings contributed greatly to the ocean harvest rate, suggesting that yearlings survive at higher rates than YOY (CDFG 2004b).

In general, Chinook salmon spend between 1 and 4 years in the ocean before returning to spawn (Myers et al. 1998). Fisher (1994) estimated that 87% of spring-run Chinook return as 3-year-olds based on data collected at Red Bluff Diversion Dam. In another study, Cramer and Demko (1997) estimated that 80 to 90% of the spring-run smolts from the Feather River Hatchery matured at age 4 and that 85% of those fish were harvested by the time they reached age 4. Based on data from the life history investigation, CDFG found that age 4 fish can make up a high percentage of the escapement in some years, ranging from 44 to 89% (CDFG 2004a). These numbers were calculated using coded-wire tag data that were standardized for release size.

# Historical Distribution

Yoshiyama et al. (2001) provided a narrative description of the historical distributional limits and abundances of Chinook within the Central Valley watersheds. Schick et al. (2005) expanded on this work using a geographic information system (GIS) to add more explicit spatial information. They grouped spring-run into four diversity units: (1) upper Sacramento spring-fed (Little Sacramento, Pit, Fall, Hat, McCloud, Battle, Mill, and Deer Creeks); (2) upper Sacramento rain driven (Butte, Big Chico, Antelope, Clear, Cottonwood/Beegum, Thomes, and Stony Creeks); (3) lower Sacramento-San Joaquin northern Sierra (Feather, Yuba, and American Rivers); and (4) lower Sacramento-San Joaquin southern Sierra (Mokelumne, Stanislaus, Tuolumne, Merced, San Joaquin, and Kings Rivers).

Lindley et al. (2007) divided spring-run into slightly different diversity units: (1) basalt and porous lava (Little Sacramento, Pit, Fall, Hat, McCloud and Battle Creeks); (2) Northern Sierra Nevada (Mill, Deer, Antelope, Butte, and Big Chico creeks and Feather, Yuba, American, and Mokelumne Rivers; (3) Northwestern California (Clear, Cottonwood/ Beegum, Thomes, and Stony Creeks); and (4) Southern Sierra Nevada (Stanislaus, Tuolumne, Merced, San Joaquin, and Kings Rivers).

This Background Report relies heavily on the historical distribution of spring-run and steelhead information presented in Yoshiyama et al. (2001) and Schick et al. (2005). Because the HEA specifies that the target of habitat expansion actions is the Sacramento River basin, this report addresses only the first three diversity units described by Schick et al. (2005).

In the upper Sacramento spring-fed unit, spring-run Chinook could have accessed approximately 43 kilometers (km) (27 miles) of habitat in the Pit River, 11.5 km (7 miles) in the Fall River, 3.5 km (2 miles) in Hat Creek, and 25 km (15.5 miles) in the McCloud River prior to the construction of Shasta Dam (Schick et al. 2005). The Pit River was a "noted salmon stream" in the late 1800s, but a substantial decline occurred prior to 1929 (Yoshiyama et al. 2001). Both the Fall River and Hat Creek are tributaries of the Pit River and were noted to support spring-run spawning, but not to the same extent as Pit River (Yoshiyama et al. 2001). Yoshiyama et al. (2001) noted that access to all of the tributaries was impeded by gold mining and irrigation activities prior to the construction of Shasta Dam.

For the tributaries below Shasta Dam, spring-run Chinook could have accessed approximately 26 km (16 miles) of habitat in Battle Creek (including both the North and South Forks), 25 km (15.5 miles) in Mill Creek, and 20.5 km (13 miles) in Deer Creek (Schick et al. 2005). All three of these tributaries naturally provided spatial separation between spring-run and fall-run (Yoshiyama et al. 2001). Reynolds et al. (1993) noted that surveys conducted prior to the construction of Shasta Dam indicated that Battle Creek could support 1,800 spawning pairs in the reaches above the Coleman National Fish Hatchery. By the 1920s, spawning reaches on both the North and South Forks were blocked by diversion dams associated with hydroelectric projects, which also altered streamflows. Clark (1929) noted that a small spring run still existed above the U.S. Bureau of Fisheries egg-collecting station and hatchery. By the 1980s, however, very few if any spring-run Chinook were observed in Battle Creek (Campbell and Moyle 1990). Spring-run Chinook have been observed in both Cow Creek and Bear Creek in low numbers (CH2M Hill 1998). Both creeks are predominantly rain fed and were probably used by spring-run only in years with above-normal rainfall (CH2M Hill 1998).

Mill Creek supported rather "large" runs of spring-run Chinook with few human-made obstacles, mainly diversion dams near the valley floor (Yoshiyama et al. 2001). Escapement ranged from <500 to 3,000 fish between 1947 and 1959 (Fry 1961). Overall, the trend was downward between the 1940s and the 1980s, from an annual average of 2,000 to about 300 fish (CDFG 1990).

Deer Creek also had a strong population of spring-run until diversion dams were built and reduced instream flows (Clark 1929). Habitat in Deer Creek was expanded by about 5 miles above Lower Deer Creek Falls in the early 1940s to mitigate for the construction of Shasta Dam (Needham et al. 1941). Deer Creek has adequate habitat to support a sustainable population of 4,000 spring-run but insufficient flows can impede or prevent upstream passage (Reynolds et al. 1993). Like Mill Creek, escapement ranged from <500 to 4,000 fish between 1940 and 1956 (Fry 1961). The escapement decreased between the 1940s and the 1990s from an average annual of 2,200 to 660 fish (Yoshiyama et al. 2001).

For the east side tributaries in the upper Sacramento rain-fed unit, spring-run Chinook had access to approximately 14.5 km (9 miles) of habitat in Antelope Creek, 29 km (18 miles) in Butte Creek, and 11 km (7 miles) in Big Chico Creek (Schick et al. 2005). Access and use of these tributaries have been limited by water diversions since the 1920s (Yoshiyama et al. 2001).

Antelope Creek historically supported a low number of spring-run Chinook with an estimated escapement of approximately 500 fish (Reynolds et al. 1993). Reynolds et al. (1993) noted that operations of two water diversions during the irrigation season impede or prevent the upstream migration of spring-run in most years. Big Chico Creek also supported low numbers of spring-run and was primarily used opportunistically (Reynolds et al. 1993). Reynolds et al. reported that the population was <500 during the 1950s and 1960s, and dropped to <200 fish in the 1990s. Butte Creek historically supported the largest population of the three tributaries but was heavily impacted by water diversions, dams, and weirs by the 1920s (Clark 1929). CDFG (1960) reported adults still being lost to unscreened diversions as late as 1958 to 1960. Extensive mining and hydroelectric development also reduced the amount of suitable habitat in the watershed (Hanson et al. 1940). Escapement ranged from <500 to 3,000 fish in the 1950s but dropped to 100 to 700 fish by the early 1990s (Fry 1961, CDFG 1998).

The west-side tributaries of the Sacramento River, including Clear Creek, Cottonwood/Beegum Creek, Thomes Creek, and Stony Creek, also provided some suitable habitat for spring-run (Yoshiyama et al. 2001). Clear Creek provided approximately 15 km (9 miles) of suitable habitat while Cottonwood Creek provided 10 km (6 miles) and Stony Creek 28 km (17 miles) (Schick et al. 2005). These creeks, along with a dozen other small tributaries, occasionally supported small runs of <500 fish (Fry 1961). Low flows associated with irrigation noticeably affected both passage and water temperatures for spring-run by the late 1920s (Clark 1929).

Three river systems in the lower Sacramento-San Joaquin Northern Sierra unit drain into the Sacramento River: the Feather, Yuba, and American Rivers. All three river drainages historically supported a substantial number of spring-run Chinook in their upper watersheds (Yoshiyama et al. 2001). Extensive mining, irrigation, and the development of hydroelectric dams significantly reduced the amount of suitable habitat in all three drainages (Yoshiyama et al. 2001). Schick et al. (2005) estimated approximately 114 km (71 miles) of suitable habitat for spring-run in the Feather River. Spring-run used all four major tributaries of the Feather River but primarily used the Middle Fork for spawning (CDFG 1952, Fry 1961, DWR 2007). Hydropower dams and other structures blocked much of the historical habitat prior to the construction of Oroville Dam in 1967, which formed a complete barrier for migration into the upper watershed.

The Yuba River contributed 19.5 km (12 miles) of habitat. Much of this habitat was seriously impacted by both diversion dams and mining activities starting in the late 1800s (Schick et al. 2005, Reynolds et al. 1993). Most of the available habitat was found on the North Fork, but the Middle and South Forks also were used by spring-run (Yoshiyama et al. 2001). Yoshiyama et al. (2001) noted that access to all forks was greatly impeded by Daguerre Point Dam around 1910 and was blocked completely with the completion of Englebright Dam in the late 1930s.

The American River contributed an additional 80.5 km (50 miles) of suitable habitat historically, but access to this habitat was impeded by construction of diversion dams and was completely blocked in 1955 by completion of Folsom and Nimbus Dams. Prior to completion of these dams, spring-run used all three forks of the American River. Spring-run likely used the North Fork up to the falls at

Royal Gorge, the Middle Fork up to the confluence with the Rubicon River, and the South Fork up to the waterfall at Eagle Rock (Yoshiyama et al. 1996).

# Current Distribution

In the upper Sacramento spring-fed unit, spring-run Chinook no longer have access to the Pit River, the Fall River, Hat Creek, the McCloud River, or the Little Sacramento River due to construction of Shasta Dam (Schick et al. 2005). For the tributaries below Shasta Dam, spring-run Chinook access to Deer and Mill creeks remains essentially unchanged. However, much of the historical habitat on Battle Creek is no longer accessible (Schick et al. 2005). Approximately 2.9 km (2 miles) of habitat on the mainstem remains accessible, but access is blocked on both the North and South Forks.

For both the east-side and west-side tributaries of the Sacramento River in the upper Sacramento rain-fed unit, the amount of available habitat for spring-run Chinook remains essentially the same (Schick et al. 2005). However, access and use of these tributaries are limited by water diversions. Spring-run habitat on Stony Creek was blocked due to construction of Black Butte Reservoir and is no longer used by spring-run Chinook (Reynolds et al. 1993). In all of the other tributaries, except Butte Creek, only remnant spring-run populations remain (Yoshiyama et al. 2001). The Butte Creek population has been increasing over the last decade due to passage improvements made in the late 1990s (CDFG 2004b).

In the lower Sacramento-San Joaquin Northern Sierra unit, much of the historical habitat is blocked by dams. On the Feather River, only 35 km (22 miles) of habitat on the mainstem below Oroville Dam remains, and there is no spatial or temporal separation between spring-run and fall-run Chinook (Schick et al. 2005). This has resulted in the hybridization of the two runs from in-river spawning and past hatchery operations (Yoshiyama et al. 2001). However, an early-returning population persists within both the Feather and Yuba Rivers and is supported by Feather River Hatchery operations (Yoshiyama et al. 2001, DWR 2007, Lindley et al. 2007). On the Yuba River, most of the historical habitat was blocked by construction of Daguerre Point and Englebright Dams. Access to the North Yuba, Middle Yuba, and South Yuba Rivers is blocked, leaving about 12 km (7.5 miles) of spawning habitat on the lower Yuba River below Englebright Dam (Schick et al. 2005). The Yuba River has experienced the same problem with hybridization between spring-run and fall-run due to the lack of spatial and temporal separation (Yoshiyama et al. 2001). There is no suitable habitat for spring-run on the American River below Nimbus Dam.

# Population Viability Assessment

In 2000, NMFS published a technical memo describing the viable salmonid population (VSP) concept and providing guidance for determining the conservation status of populations (McElhany et al. 2000). Lindley et al. (2007) built upon that work and developed a more quantitative framework for assessing the viability of Chinook and steelhead ESUs in the Central Valley.

McElhany et al. (2000) defined a viable salmonid population as an independent population that has a negligible risk of extinction over a 100-year time frame, where an independent population has one or more local breeding units whose dynamics are not substantially altered by exchanges of individuals with other populations. McElhany et al. used four parameters (abundance, population growth rate, population spatial structure, and diversity) to evaluate population viability status. The following discussion of the four parameters is drawn from their report.

According to the abundance VSP guidelines, a viable population size would meet the following criteria: (1) large enough to have a high probability of surviving environmental variation comparable to what has been observed in the past and expected in the future; (2) large enough for compensatory processes to provide resilience; (3) large enough to maintain genetic diversity over the long term; (4) large enough to provide important ecological functions throughout its life cycle; and (5) population estimates on average are above the population targets over a period of time. If the population size meets any of the following critical size guidelines, it cannot be considered viable: (1) depensatory processes are likely to reduce it below replacement; (2) risk of inbreeding or fixation of deleterious mutations; (3) high risk of productivity variation due to demographic stochasticity (population highly unpredictable); or (4) population estimates on average are below the population targets over a short period of time.

When estimates of population growth rates indicate that a population is consistently failing to replace, the risk of extinction is increased regardless of the cause. McElhany et al. (2000) focused on the population growth rate over the entire life cycle but noted that it is also important to estimate stage-specific productivity when evaluating population viability. Even if stage-specific declines do not result in a reduction in the total population, they may indicate a lack of resilience to variation. On the other hand, a viable population would meet the following population growth rate VSP guidelines: (1) natural productivity is sufficient to maintain abundance above the viable level (cohort-replacement rate ≥ 1); (2) if the population includes naturally spawning hatchery fish, the productivity of the naturally produced spawners is sufficient to maintain abundance at or above viability thresholds without the hatchery subsidy; (3) productivity is sufficient during freshwater life history to maintain a viable abundance even during poor ocean conditions; (4) does not exhibit sustained declines that span multiple generations and multiple brood-year cycles; (5) does not exhibit trends or shift in traits (i.e., the size and age of spawners) that portend declines in the growth rate; and (6) has an adequate time series of abundance to detect ecologically significant trends before substantial changes to abundance have occurred.

The spatial structure guidelines address both the geographic distribution of individuals and the processes that generate that distribution. Because a population's structure depends on habitat quality, spatial configuration, dynamics, and the dispersal characteristics of the individuals the VSP guidelines include (1) habitat patches that are not destroyed faster than they are naturally created; (2) natural straying rates among subpopulations is not be substantially increased or decreased by human actions; (3) some suitable or marginally suitable habitat patches that currently contain no fish are maintained; (4) source subpopulations are maintained; and (5) historical spatial processes are preserved as a default goal.

Diversity (i.e., variation in traits) within and among populations is important for population viability. Salmon traits such as anadromy, morphology, fecundity, run timing, spawn timing and behavior, juvenile behavior, age at smolting and maturity, egg size, developmental rate, ocean distribution, and genetic characteristics allow for considerable diversity. Nevertheless, any actions that affect basic demographic and evolutionary processes can affect a population's diversity. Diversity guidelines for a viable population include (1) variation in traits such as run timing, age structure, size, fecundity, morphology, behavior, and molecular genetic characteristics that are not substantially altered by human-caused factors; (2) natural processes of dispersal are maintained and human-caused factors do not substantially change the gene flow rate among populations; (3) natural processes that cause ecological variation are maintained; and (4) historical phenotypic diversity is used as a default goal in maintaining viable populations.

McElhany et al. (2000) also developed guidelines for assessing the viability of ESUs. The guidelines are (1) the ESU has multiple populations; (2) some populations are geographically widespread; (3) some populations are geographically close; (4) populations do not all share common catastrophic risks; (5) populations display diverse life histories and phenotypes; (6) some populations exceed VSP guidelines; and (7) historical number and distribution of populations are used as a default goal for maintaining viable ESUs.

Using a criteria-based assessment, Lindley et al. (2007) found that the Central Valley spring-run ESU is not viable because only a small portion of the historical ESU is represented and the remaining populations are vulnerable to catastrophic disturbance. However, those existing populations are at low risk of extinction. Lindley et al. (2007) identified four ecoregions within the ESU historically: (1) basalt and porous lava region; (2) northern Sierra Nevada region; (3) southern Sierra Nevada region; and (4) Northwestern California region. The only viable spring-run Chinook populations remaining are in the northern Sierra Nevada region (Butte, Mill, and Deer Creeks). This current distribution leaves the ESU vulnerable to catastrophic disturbances from volcanic activity (Mt. Lassen), drought, and wildfires.

Butte Creek and Deer Creek spring-run populations satisfied both the population viability assessment (PVA) and other viability criteria putting them at low risk of extinction while Mill Creek is at moderate risk of extinction based on the PVA but satisfies other viability criteria (Lindley et al. 2007). Some uncertainty remains about whether Mill and Deer Creek populations are independent or if they belong to a single larger population (Lindley et al. 2004). Lindley et al. (2007) also noted the presence of ephemeral or dependent populations in the Northwestern California region. Due to insufficient data, they were not able to assess the status of the early-returning Chinook within the Feather River Hatchery population that spawn in both the Feather and Yuba Rivers.

Viability assessments use conditions from the recent past to address whether a population will persist in the future. Future conditions are unlikely to be similar to the recent past, however, because of expected climatic changes. Lindley et al. (2007) noted that the criteria they proposed may not offer sufficient protection if a prolonged period of unfavorable climatic conditions occurs. Regional-scale climate models for California broadly agree that future temperatures will be warmer and that total precipitation may decline with a significant decline in snowfall. Given these changes, all Central Valley salmonids are likely to be negatively affected, especially those using freshwater in summer (Lindley et al. 2007). Lindley et al. noted that habitat availability will decrease as the lower distributional limit rises, given the current upper distributional limits due to dams.

Lindley et al. (2007) assessed three different scenarios for the potential increase in mean summer temperature by 2100 and its effect on the availability of historical habitat above the 25 °C isotherm. Under the most conservative increase of 2 °C, the loss of historical habitat would be low except for in the southern Sierra eco-region and in Butte Creek (Lindley et al. 2007). With a more likely increase of 5 °C, historical habitat loss would be significant with some remnant habitat in the upper reaches of the basalt and porous lava (Pit and McCloud Rivers) and the northern Sierra ecoregions (Battle and Mill Creeks, and Feather and Yuba Rivers). Under this scenario, most of the remaining habitat would be found on the Feather and Yuba Rivers. Lindley et al. (2007) also estimated that, under an 8 °C increase, spring-run habitat would be found only in the uppermost reaches of the North Fork Feather River, Battle Creek, and Mill Creek. Changes in hydrology are also are expected to impact Central Valley salmonids by reducing the quantity and quality of freshwater habitat.

# Central Valley Steelhead

## Listing Status

As noted, in 1998, NMFS listed the Central Valley steelhead ESU as threatened under the federal ESA (NMFS 1998). This ESU includes all naturally spawned populations of steelhead in the Sacramento and San Joaquin Rivers and their tributaries (NMFS 1998 as cited in DWR 2007). The original critical habitat designation was withdrawn, and NMFS published a final designation of critical habitat in 2005 (DWR 2007). The critical habitat designation includes the Sacramento, lower Feather, and Yuba Rivers; Battle, Cottonwood, Antelope, Mill, Deer, Butte, and Big Chico Creeks; and the Cosumnes, Mokelumne, Calaveras, and San Joaquin Rivers and tributaries to the San Joaquin (NMFS 2004).

## General Life History

The life history of steelhead is more complex than other Pacific salmonids; steelhead exhibit both anadromous and freshwater resident traits. The freshwater residents are referred to as rainbow trout. Steelhead are divided into two basic reproductive ecotypes. Stream-maturing steelhead, also referred to as *summer steelhead*, are sexually immature upon freshwater entry and mature in the river over the summer (Busby et al. 1996). The ocean-maturing steelhead, or winter steelhead, enter freshwater with well developed gonads and spawn soon after reaching the spawning grounds. Unlike Chinook, steelhead are iteroparous (capable of spawning more than once), but they rarely spawn more than twice (Busby et al. 1996). Historically, both summer and winter steelhead were found in the Central Valley (Needham et al. 1941). Currently, only winter steelhead have been identified in the Central Valley (McEwan 2001).

Winter steelhead enter freshwater between August and April, and spawning occurs from December to May (Busby et al. 1996, NMFS 2002). In the Sacramento River basin, spawning generally peaks between January and March (NMFS 2002). Steelhead use cool, well oxygenated water with velocities ranging from 1 to 3.6 feet per second for spawning (McEwan 2001). The incubation time depends on water temperature, dissolved oxygen concentration, and substrate; fry generally emerge in late spring (NMFS 2002). The fry use shallow water along perennial streambanks, where they establish and defend feeding stations (Nickelson et al. 1992, McEwan 2001).

YOY steelhead primarily use higher velocity areas in pools for rearing but are also known to use glides and riffles (NMFS 2002). Juveniles use a wider range of habitat types but prefer areas with large and small woody debris and overhead cover (McEwan 2001, NMFS 2002). Older juveniles can also move downstream to rear in larger tributaries or rivers (Nickelson et al. 1992). The juveniles will reside in freshwater from 1 to 4 years and typically emigrate between February and April (NMFS 2002). Central Valley steelhead generally spend 1 to 2 years in the ocean before returning to spawn (Busby et al. 1996).

Recent studies have shown that Central Valley steelhead and rainbow trout are polymorphic, finding that anadromous females can produce non-anadromous progeny and non-anadromous females can produce anadromous progeny (McEwan 2001, Zimmerman et al. 2008). Research by Zimmerman et al. (2008) suggests that the portion of steelhead progeny may differ between location and years.

# Historical Distribution

Information on the historical distribution of Central Valley steelhead is limited and not as well documented as for Central Valley Chinook salmon. McEwan (2001) provides evidence supporting the conclusion that steelhead distribution can be inferred from Chinook salmon distribution, especially spring-run Chinook salmon which has many of the same requirements for spawning and rearing. Yoshiyama et al. (1996) concluded that steelhead distribution was probably broader than Chinook salmon:

> *[Steelhead were] undoubtedly more extensively distributed [than Chinook salmon in the Central Valley]. Due to their superior jumping ability, the timing of their upstream migration, which coincided with the winter rainy season, and their less restrictive preferences for spawning gravels, steelhead could have used at least hundreds of miles of smaller tributaries not accessible to the earlier-spawning salmon.*

The available information indicates that steelhead used both the Sacramento River and San Joaquin River basins from the Pit River south to the Kings River (McEwan 2001). Like Chinook salmon, extensive mining, dams, and low flows impacted the distribution of steelhead starting in the late 1800s.

Lindley et al. (2006) reconstructed the historical distribution and population structure using models to predict the spatial location of stream locations and identifying suitable habitats within stream segments. They identified 81 independent populations of steelhead within four major subdivisions in the Central Valley ESU. The four subdivisions are (1) Sacramento River basin; (2) Suisun Bay area tributaries; (3) San Joaquin tributaries draining the Sierra Nevada; and (4) streams that drained to the Buena Vista and Tulare basins. Like McEwan (2001) and Yoshiyama et al. (1996) they found that *O. mykiss* was probably more abundant in the Sacramento basin than in the San Joaquin basin. The San Joaquin tributaries have steeper gradients and sometimes lower flow and therefore have more natural barriers to migration (Lindley et al. 2006).

This report focuses on the distribution of steelhead in the Sacramento River basin.

# Current Distribution

The current distribution is limited in most areas due to impassable dams in the Central Valley. Reynolds et al. (1993) reported that approximately 95% of the historical habitat has been lost due to both mining and water development activities.

Because of limited steelhead monitoring efforts, the current distribution is not clearly known (McEwan 2001). Based on Chinook monitoring data collected by CDFG and USFWS, steelhead are still found in several upper Sacramento tributaries, including Clear, Antelope, Deer, Mill, Butte, and Battle Creeks (Busby 1996, Low et al. 2007). Lindley et al. (2006) reported that historical habitat may still be accessible in a few streams including Mill, Deer, Butte, and Cottonwood Creeks. Naturally spawning steelhead are also found on the American, Feather, Yuba, Mokelumne, and mainstem Sacramento Rivers; but the hatchery influence on these fish remains unknown (Busby et al. 1996). Changes to the thermal regime and food web structure (Lieberman et al. 2001) on these regulated rivers may be more beneficial for the resident forms, thus altering the proportion of anadromous to resident forms in these larger rivers.

## Population Viability Assessment

Lindley et al. (2007) were not able to quantitatively assess the viability of Central Valley steelhead due to data deficiencies. Although they did not find any evidence of a low extinction risk for the ESU, the significant loss of historical habitat, habitat fragmentation, and degradation are likely adversely affecting both the anadromous and resident *O. mykiss* populations. Based on qualitative data and assessment of hatchery-supported populations, Lindley et al. (2007) determined that the existing populations are not viable and that the Central Valley ESU has a moderate to high risk of extinction.

Like spring-run Chinook, Central Valley steelhead populations are susceptible to the impacts of the predicted climate changes addressed by Lindley et al. (2007). Because spring-run and steelhead currently use much of the same habitat in the Sacramento River basin, steelhead will probably be affected much to the same extent in the tributaries as described for spring-run.

# Restoration Activities in the Sacramento River Basin

## Central Valley Project Improvement Act

In the mid-1990s, several state and federal restoration programs were developed to protect and restore anadromous salmonid populations within the Central Valley. The Central Valley Project Improvement Act (CVPIA) was amended to assign equal priority to fish and wildlife protection, restoration, and mitigation as to other Central Valley Project (CVP) projects (Reclamation and USFWS 2001). Under Section 3406 of the CVPIA, the Department of Interior was required to implement the Anadromous Fish Restoration Program (AFRP) which includes reoperation of the CVP to achieve the goals outlined in the AFRP Final Restoration Plan, implementing a Habitat Restoration Program, and dedicating 800,000 acre-feet of CVP yield annually for fish and wildlife (known as *(b)(2) water*) on CVP-operated rivers and streams (Reclamation and USFWS 2001). The CVP yield is used to improve upstream flows, meet water quality standards set forth in State Water Board Decision D-1641, and reduce entrainment at the CVP pumping facility in Tracy. The CVPIA also requires implementation of a supplemental water acquisition program, anadromous fish flow pulses, elimination of flow fluctuations, Clear Creek restoration, gravel replenishment, a Comprehensive Assessment and Monitoring Program, and an Anadromous Fish Screen Program (Reclamation and USFWS 2001).

The CVPIA required the Secretary of the Interior to develop and implement the AFRP, which was to make all reasonable efforts to ensure that by 2002 the natural production of anadromous fish in the Central Valley rivers and streams be self-sustaining at levels at least double the average levels from 1967 to 1991 (USFWS 2001). In 1995, the AFRP Core Group prepared a Working Paper on Restoration Needs; in 2001, they completed the Final Restoration Plan for the AFRP. Since the mid-1990s, USFWS has implemented AFRP restoration activities on several tributaries in the upper Sacramento River basin, including Mill, Deer, Butte, Clear, and Battle Creeks, to support these restoration goals.

As the amended CVPIA was being implemented, other programs were being developed, including CALFED and the Trinity River Mainstem Fishery Restoration Program (Reclamation and USFWS 2001). In light of that, many CVPIA efforts were coordinated with CALFED efforts in the Central Valley, especially the CALFED Ecosystem Restoration Program (ERP), as described below.

## CALFED

In 1994, state and federal agencies joined with stakeholders and agreed to the Bay-Delta Accord, an agreement to develop a long-term comprehensive plan to restore the Bay-Delta for all beneficial uses. The Bay-Delta Accord led to the formation of CALFED, a cooperative effort to restore the ecological health of the Bay-Delta, improve water supply reliability, protect drinking water quality, and protect Delta levees (Reclamation and USFWS 2001). One of the several programs created through this process was the ERP.

The ERP was designed to maintain, improve, and increase both aquatic and terrestrial habitats in the Bay-Delta through the restoration of ecological processes (CALFED 2001). The ERP also was designed to recover at-risk species, such as anadromous salmonids, that are dependent on the Delta. The ERP is implemented using an ecosystem-based adaptive management approach with defined goals and objectives for ecosystem habitat and species rehabilitation projects (CALFED 2001). Three types of management actions (targeted research, pilot or demonstration projects, and full-scale implementation projects) are funded through the ERP (CALFED 2001). Since 1997, the ERP has funded numerous restoration projects in the upper Sacramento River basin.

NMFS is currently preparing a recovery plan for winter and spring-run Chinook and Central Valley steelhead. A co-manager review draft of the recovery plan was released in May 2008 that identified numerous recovery actions for the Sacramento River basin tributaries to benefit spring-run Chinook and steelhead. These actions include identifying and implementing projects to improve water temperature (reduce fire risk, restore meadows, and increase riparian shade), conduct fish passage evaluations at agricultural diversions, evaluate and dedicate instream flows to facilitate passage, implement gravel augmentation projects, fortify streambanks to reduce fine sediments, monitor water quality, and modify sport fishing regulations (NMFS 2008).

# Sacramento River Basin Tributaries: Status of Spring-Run Chinook Salmon and Steelhead

Table B-1 displays the historical estimates of spring-run Chinook salmon escapement in the Sacramento River basin tributaries along with the range of escapement estimates for the period from 1960 to 2007. Figures B-1 through B-3 display the estimated adult spring-run populations from 1960 to 2007 in tributaries where estimates are available.

Data acquired from CDFG GrandTab. Data for 2005 to 2007 are preliminary and subject to revision.

The Feather River estimate includes both in-river and hatchery counts. Data acquired from CDFG GrandTab. Data for 2005 to 2007 are preliminary and subject to revision.

Data acquired from CDFG GrandTab. Data for 2005 to 2007 are preliminary and subject to revision.

For this report, monitoring information was taken from the Central Valley Salmon and Steelhead Monitoring Program Summary (Low et al. 2007) unless otherwise stated. This report focuses on the monitoring activities for adult salmonids and does not include information on juvenile salmonid monitoring in the Central Valley.

The following sections describe the spawning/holding habitat, rearing habitat, monitoring activities, limiting factors, and restoration activities for tributaries that are known to support spring-run Chinook or steelhead in the upper Sacramento River basin.

**Table B-1** Escapement Estimates for Spring-Run Chinook in the Sacramento River Basin Tributaries from Historical Records and Monitoring Data (1960–2007)

| Tributary | Historical Abundance | Source | CDFG GrandTab Estimate 1960–2007 (min–max) |
|---|---|---|---|
| Battle Creek | 1,700–2,200; 1,800 | CDFG (1998); Reynolds et al. (1993) | 2–291 |
| Cow Creek | unknown | | No survey for spring-run |
| Bear Creek | unknown | | No survey for spring-run |
| Clear Creek | < 500 | Fry (1961) | 0–194 |
| Antelope Creek | <= 500 | Reynolds et al. (1993) | 0–154 |
| Mill Creek | 300–3,000; <= 3,500; 3,000–4,000 | Fry (1961) & CDFG (1990); CH2M Hill (1998); CDFG (1998) | 61–3,500 |
| Deer Creek | 500–4,000 | Fry (1961) & Yoshiyama et al. (2001) | 84–8,500 |
| Butte Creek | 100–3,000 | Fry (1961) & CDFG (1998) | 10–20,259 |
| Big Chico Creek | < 200–500; 1,000 | Reynolds et al. (1993); CH2M Hill (1998) | 0–500 |
| Cottonwood Creek | <= 500 | Fry (1961) | 0–477 |
| Thomes Creek | < 500 | Fry (1961) | 0–2 |
| Stony Creek | < 500 | Fry (1961) | (Extirpated) |
| Feather River (in-river) | 1,700; 500–4,000; 8,000–20,000 | CH2M Hill (1998); CDFG (1998) & Fry (1961); Moyle (2002) | 2–2,908 |
| Yuba River | unknown; 6,000–10,000 | no early CDFG records; Moyle (2002) | 108–200 |
| American River | unknown; >= 10,000 | no early CDFG records; Moyle (2002) | (Extirpated) |

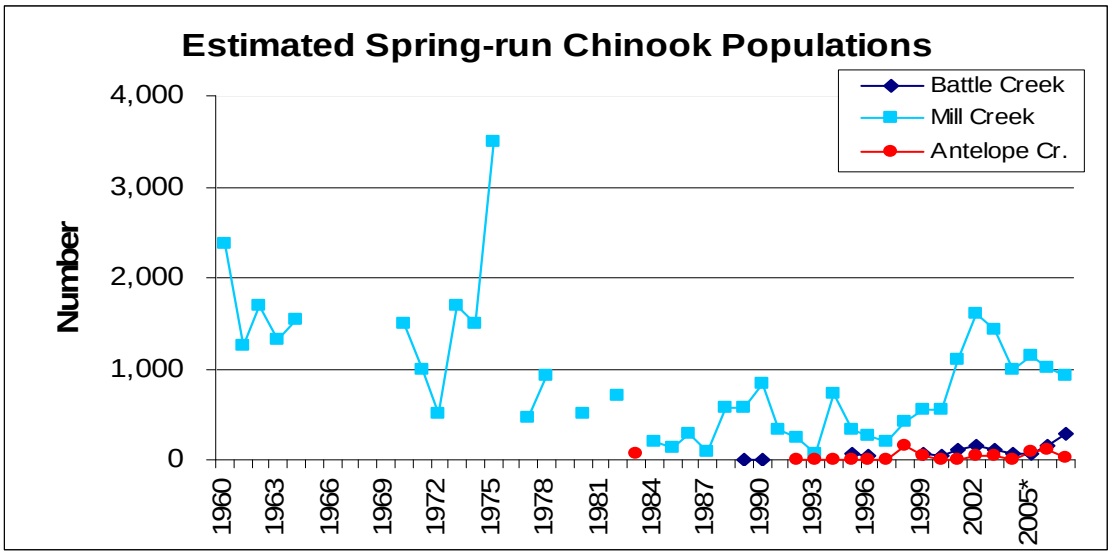


**Figure B-1** Estimated Adult Spring-Run Chinook Populations for Battle, Mill, and Antelope Creeks (1960–2007)

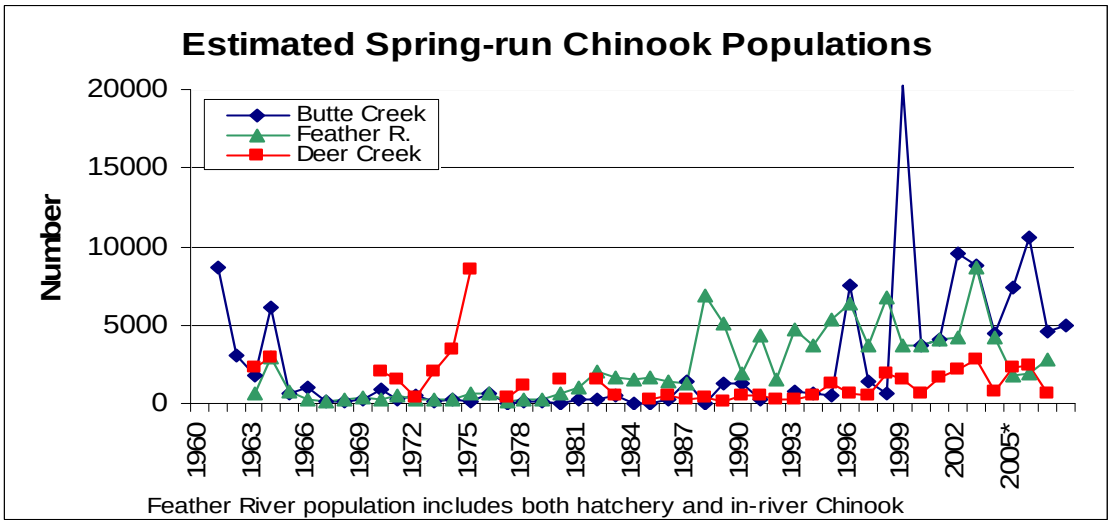


**Figure B-2** Estimated Adult Spring-Run Chinook Populations for Butte Creek, Deer Creek, and Feather River (1960–2007)

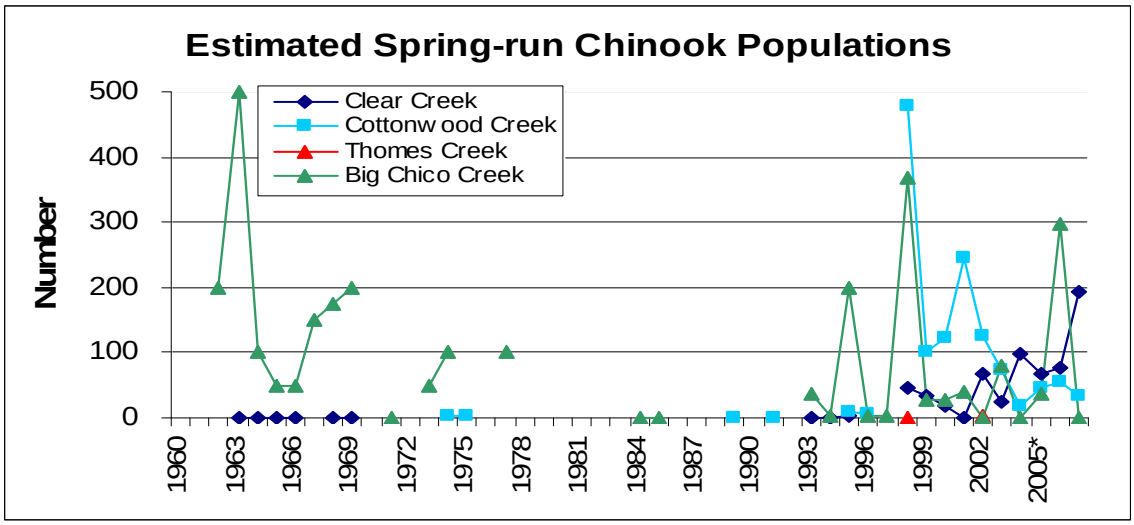


**Figure B-3** Estimated adult spring-run populations for Clear, Cottonwood, Thomes, and Big Chico Creeks (1960–2007)

# Clear Creek

## Spawning/Holding Habitat

Clear Creek is approximately 18.1 miles long between the confluence with the Sacramento River and Whiskeytown Dam. Whiskeytown Dam is a total barrier to salmonid migration in Clear Creek. The elevation for this reach drops from 1,000 feet to 400 feet above mean sea level (Newton and Brown 2004). USFWS identified two predominant stream channel types in Clear Creek. The upper reaches from Whiskeytown Dam down to Clear Creek Road Bridge (River Mile [RM] 8.5) have steep canyon walls with falls, high-gradient riffles, and deep pools. Below Clear Creek Road Bridge, the stream channel widens into an alluvial reach with a much lower gradient.

Since 2001, the Dedicated Project Yield Program—authorized by Section 3406(b)2 of the CVPIA—has provided additional water year-round to increase streamflow. The increased flows and resulting lower water temperatures improve passage, holding, spawning, and rearing conditions for both spring-run Chinook and steelhead (Giovannetti and Brown 2007). The goal of the flow targets is to provide access to 90% of the maximum possible weighted usable area (Reclamation and USFWS 2007).

The additional streamflows to manage water temperature also allow fall-run Chinook to access the reaches above Gorge Cascade (RM 6.5). Because USFWS was concerned about the effects of hybridization and redd superimposition between spring-run and fall-run Chinook, they installed a temporary picket weir at RM 8.09 in 2003 (Newton and Brown 2005). The weir limits spring-run Chinook to approximately 10 miles of spawning and holding habitat but ensures spatial separation of the two runs. The weir is installed in late August and removed in early November to allow steelhead access to the entire creek.

Water temperatures are managed to support spring-run spawning and egg incubation. Water temperature is maintained at <56 °F at the Igo gage (RM 10.8) for spring-run spawning from

September 15 through October 30 under the biological opinion for the operation of the CVP and the State Water Project (NMFS 2002).

Gravel augmentation has substantially increased the amount of spawning habitat for both Chinook and steelhead in Clear Creek (Giovannetti and Brown 2007). Smaller gravel has been injected below Whiskeytown Dam specifically to improve steelhead spawning. Giovannetti and Brown (2007) found that 30 to 40% of the steelhead redds had injection gravel in them between 2001 and 2007, suggesting that habitat is still limiting spawning or that the gravel injection is providing more suitable spawning habitat for steelhead.

## Rearing Habitat

Brown (1996) calculated the change in percent of optimum habitat at various instream flows and estimated a 15% increase in rearing habitat when flows were increased from 50 to 150 cubic feet per second (cfs). Currently, flows are maintained at 200 cfs from mid-September through mid-June to support juvenile salmonid rearing and emigration.

USFWS and the CALFED Environmental Water Program (EWP) are currently working with the U.S. Bureau of Reclamation (Reclamation) to reoperate Whiskeytown Dam in spring to reactivate fluvial processes within Clear Creek (Reclamation and USFWS 2007). The reoperation would involve producing a 1-day flow of 3,250 cfs three times in a 10-year period. The process would help support juvenile salmonid rearing by re-creating and maintaining diverse instream and floodplain habitat in Clear Creek. In addition, ongoing floodplain and channel reconstruction projects have helped restore the natural form and functions to rearing habitat in the lower watershed (Giovannetti and Brown 2007).

## Monitoring Activities

USFWS staff conducts a snorkel survey monthly from late April through August and twice a month from September to early November to determine the relative abundance of adult spring-run Chinook in Clear Creek. Nearly the entire length of Clear Creek is surveyed starting near the mouth at RM 1.7 up to Whiskeytown Dam. The survey is also used to evaluate the distribution of immigrating and spawning Chinook. USFWS has conducted this survey annually since 1999. No long-term annual spring-run escapement surveys were conducted prior to 1999 in Clear Creek.

As part of the spring-run snorkel survey, USFWS staff counts live steelhead/ rainbow trout. USFWS also conducts a late-fall Chinook and steelhead redd survey by kayaking essentially the entire length of Clear Creek monthly from December through April. USFWS has conducted the survey since 1999, providing data on the number of steelhead/rainbow trout redds and the temporal and spatial spawning distribution within Clear Creek.

## Limiting Factors

Whiskeytown Dam remains a total barrier limiting habitat access and gravel transportation. Flow and water temperature are controlled by dam operations and could be affected by climate change. The stable flows also modify fluvial processes that can affect the quality of juvenile rearing habitat. There is also no permanent spatial separation of fall and spring-run Chinook in Clear Creek.

## Restoration Activities

Built in 1903, McCormick Saeltzer Dam (RM 6.5) was a total barrier to spring-run Chinook migration. A fish passage structure was added in 1958, but it was unsuccessful. In 1992, the structure was modified to improve fish passage. Passage increased slightly, but debris commonly blocked access through the structure (Newton and Brown 2004). The McCormick Saeltzer Dam was completely removed in 2000, providing access to the full length of Clear Creek up to Whiskeytown Dam.

The current flow schedule to increase flows and lower water temperature was developed based on an instream flow incremental methodology (IFIM) study conducted in the 1980s. The schedule may be revised based on a new IFIM study being developed by USFWS (Reclamation and USFWS 2007).

Gravel augmentation below Whiskeytown Dam started in 1995; since then, approximately 110,000 tons of gravel has been injected into the creek (Reclamation and USFWS 2007). The goal of the project is to replace the amount of spawning habitat that existed before construction of the dam by 2020. Meeting this goal will provide approximately 347,000 square feet of spawning habitat (Reclamation and USFWS 2007).

A 2-mile section in the lower portion of the creek that was significantly degraded by mining is currently being restored. Phases 1, 2A, and 2B of the Stream Channel Restoration Project were completed between 1998 and 2001. Gravel extraction pits were filled in to reduce stranding and predation and to restore floodplain function. Phase 3A was completed in 2002 by relocating a section of stream channel along with continued restoration of the floodplain. Monitoring in the new channel documented more than a 400% increase in spawning area use for fall Chinook (Reclamation and USFWS 2007). Geomorphic monitoring associated with the Stream Channel Restoration Project indicated that the stream channel and floodplain are functioning as intended and juvenile Chinook rearing was higher than expected (Reclamation and USFWS 2007). Phase 3B was completed in 2008 and involved creating spawning riffles and continuing revegetation efforts. The final phase (Phase 3C), currently in the design and permitting phase, involves realigning the stream channel and rebuilding the floodplain in the lowest reach of the restoration project to improve rearing habitat.

The extensive restoration efforts and flow supplementation have improved conditions in Clear Creek for both spring-run Chinook and steelhead. This restoration has allowed for the successful re-establishment of spring-run Chinook into the watershed and has increased the steelhead population.

# Cow Creek

## Spawning/ Holding Habitat

The Cow Creek watershed contains six major tributaries, for a combined length of 164.4 river miles (WSRCD and Cow Creek Watershed Management Group 2005). CDFG does not consider Cow Creek suitable for spring-run due to low flows, high water temperatures, and lack of holding pools (CH2M Hill 1998). However spring-run have been documented using Cow Creek and may use the watershed in above-normal water years.

The mainstem of Cow Creek does support fall-run, late fall-run, and limited steelhead spawning (<200); but the lack of summer holding pools makes it unsuitable for spring-run Chinook (SHN Consulting 2001). On Little Cow Creek, Diddy Wells Falls creates a barrier to upstream migration,

except possibly in above-normal flow years. Clover Creek provides spawning habitat up to Clover Creek Falls for fall-run and steelhead. The falls are a total barrier to upstream migration. Upper Whitmore Falls on Old Cow Creek creates a barrier to upstream migration during normal water years (SHN Consulting 2001). The available habitat, above and below the Upper Whitmore Falls, lacks holding pools and adequate spawning gravel for spring-run Chinook; but it does provide some spawning habitat for steelhead (SHN Consulting 2001).

South Cow Creek supports the most anadromous fish use in the Cow Creek watershed; spring-run Chinook have been observed below the PG&E Mill Creek Diversion Dam (SHN Consulting 2001). Adequate spawning grounds are identified above and below the diversion dam for both spring-run and steelhead. This section of the creek also has dense riparian vegetation to help moderate water temperatures (SHN Consulting 2001). Access to spawning areas can be limited in some years due to low flows.

## Rearing Habitat

Cow Creek currently provides some habitat for non-natal spring-run Chinook and steelhead rearing but is limited in most years by low flows and high water temperatures (WSRCD and Cow Creek Watershed Management Group 2005).

## Monitoring Activities

No systematic monitoring is conducted on Cow Creek for spring-run Chinook or steelhead.

## Limiting Factors

WSRCD and Cow Creek Watershed Management Group (2005) identified several factors limiting Chinook populations in Cow Creek, including flows, water temperature, and the lack of fish ladders and screens on diversions. Low flows are caused by numerous irrigation and hydroelectric diversions, and currently Cow Creek is fully adjudicated. Predation of juvenile Chinook by Sacramento pikeminnow, smallmouth bass, and largemouth bass also may be a limiting factor in the lower portions of Cow Creek (SHN Consulting 2001) Grazing, habitat conversion, non-native plants, and land management have altered the vegetation (WRSCD and Cow Creek Watershed Management Group 2005). In addition, fire suppression management has resulted in higher potential for catastrophic wildfires. SHN Consulting (2001) noted that Cow Creek does not have a major storage dam, allowing a more natural hydrograph. Because many diversions do not have minimum flow requirements, flow is limited in most years.

## Restoration Activities

The Cow Creek Watershed Management Group worked in partnership with the Western Shasta Resource Conservation District (RCD) to develop the Cow Creek Watershed Management Plan (CCWMP). The CCWMP outlines specific steps to enhance the watershed in each of five categories: water quality and quantity, fisheries, botanical and wildlife resources, fire prevention and fuel management, and education and outreach (WSRCD and Cow Creek Watershed Management Group 2005). The CCWMP objectives for anadromous fish include addressing monitoring needs, developing programs to install screens and ladders, and implementing actions to increase instream flows. The CCWMP also identifies objectives for monitoring water quality, improving water quality

and quantity, protecting and enhancing riparian corridors, and fuel management to avoid catastrophic fires within the watershed.

In March 2009, PG&E filed a License to Surrender Application with FERC for the Kilarc-Cow Creek Hydroelectric Project, FERC No. 606 (Kilarc-Cow Creek Project). As part of the process, PG&E will decommission and remove the Kilarc Development on Old Cow Creek and the Cow Creek Development on South Cow Creek (PG&E 2007a). The Kilarc-Cow Creek Project includes several small diversion dams, approximately 7 miles of water conveyance facilities, and two powerhouses. The project diverts water from North and South Canyon Creeks, Old Cow Creek, Mill Creek, and South Cow Creek (PG&E 2007a). PG&E holds three pre-1914 water rights for a combined diversion of 62 cfs in Old Cow Creek and two pre-1914 water rights for a combined diversion of 70 cfs in South Cow Creek (PG&E 2007a). The Cow Creek Adjudication (decree entered 1969) states that, if the Kilarc-Cow Creek Project is authorized or ordered to decommission, the water rights will be transferred to and used by a resource agency to protect, preserve, or enhance aquatic resources (PG&E 2007a). Decommissioning and removal of the Kilarc-Cow Creek Project should improve passage for Chinook and steelhead in both Old Cow Creek and South Cow Creek.

South Cow Creek has the most suitable spawning and holding habitat for spring-run Chinook in the Cow Creek watershed; however, there is a potential for spatial and temporal overlap with fall-run Chinook.

Restoration of Cow Creek would likely provide more benefits for steelhead than for spring-run Chinook due to the lack of holding habitat in Cow Creek. Past estimates by CDFG suggested that Cow Creek could support steelhead runs of approximately 500 (CDFG 1965 as reported in SHN Consulting 2001).

# Bear Creek

## Spawning/ Holding Habitat

Bear Creek is a small east-side tributary where rainfall is the primary source of flow (CH2M Hill 1998). Although salmon have access to approximately 24 miles, in low-flow years, the stream can run dry prior to reaching the Sacramento River because diversions exceed the natural flow (CH2M Hill 1998). Due to low flows, warm water temperatures, and lack of large holding pools, only fall-run Chinook and steelhead use Bear Creek consistently (ENPLAN 2006). Spawning runs were estimated at 300 fall-run and 200 steelhead in the 1960s; because no systematic surveys are conducted in Bear Creek, the current population of steelhead is unknown (ENPLAN 2006). Spring-run are not known to spawn in Bear Creek (CDFG 1993). Steelhead have been documented using the mainstem of Bear Creek, North Fork Bear Creek, and Snow Creek. There are no known barriers to migrations in these reaches; however, low flows may prevent adult steelhead from accessing them (ENPLAN 2006).

## Rearing Habitat

Non-natal juvenile spring-run Chinook have been reported to use Bear Creek in above-normal water years (ENPLAN 2006). Rearing habitat is a function of the natural hydrologic regime in the Bear Creek watershed; many creeks become intermittent or completely dry in years with below-average precipitation, thus limiting steelhead rearing (ENPLAN 2006). Water diversions in the lower portion of the watershed further reduce rearing habitat for both non-natal spring-run and steelhead.

## Limiting Factors

The primary factor limiting spring-run Chinook use of Bear Creek is low flow and the associated increased water temperatures. Limited holding pools; unscreened agricultural diversions; and the effects of timber harvest, fire management, and predation also are limiting factors in this watershed (ENPLAN 2006). DWR is currently conducting a fish passage barrier assessment on Bear Creek, but no recent surveys have been conducted on the amount of suitable spawning habitat and holding pools that exists in the Bear Creek watershed.

## Monitoring Activities

No annual monitoring is conducted on Bear Creek for spring-run Chinook or steelhead.

## Restoration Activities

The Bear Creek Watershed Group was formed in 2002. With the help of the Western Shasta RCD, they completed both a watershed assessment and water management plan in 2006. Each of the implementation plans outlined in the management plan will be developed as funding becomes available (WSRCD 2006).

The hydrology and water quality objectives include developing and implementing a long-term monitoring program, establishing a baseline geomorphology for the major streams, and implementing projects to increase water quantity and quality within the Bear Creek watershed. The botanical objectives include conducting vegetation inventories, protecting and restoring riparian corridors, and developing a management strategy for non-native species. The fisheries objectives include establishing a comprehensive monitoring program for anadromous species and developing a program to assist landowners to install screens and ladders at diversions. Other objectives focus on land use and fire and fuels management, and education and outreach within the watershed (WSRCD 2006.)

Historically, this watershed supported only small populations of both Chinook and steelhead. Therefore, while these restoration actions will improve conditions in Bear Creek, the opportunity for establishing independent self-sustaining populations is limited.

# Cottonwood/Beegum Creeks

## Spawning/ Holding Habitat

The Cottonwood Creek watershed encompasses 929 square miles and has three main tributaries, the South Fork, the North Fork, and Beegum Creek (off the Middle Fork), which provide approximately 130 miles of Chinook spawning habitat (CH2M Hill 2007). Like Clear Creek, Cottonwood Creek has steep, narrow canyons starting from the headwaters and transitioning to braided alluvial streams in the valley reach (CH2M Hill 2002).

Spring-run spawning and holding habitat is limited primarily to Beegum Creek and the South Fork above Maple Creek (CH2M Hill 1998); however, some spawning has been documented on the North Fork (CH2M Hill 2002). Several natural partial barriers can block migration into portions of Beegum Creek under certain flow conditions; on the South Fork, a human-made barrier exists about 3.5 miles upstream of Maple Creek (CH2M Hill 2002). Prior to this barrier, spring-run were

observed 7 to 8 miles upstream of Maple Creek (CH2M Hill 2002). On the North Fork, a natural barrier is upstream of the Ono Bridge. Historical records indicate that up to 500 spring-run spawned in Cottonwood and Beegum Creeks (CH2M Hill 2007).

Steelhead utilize all the forks and the mainstem of Cottonwood Creek. Approximately 42% of the mainstem has suitable spawning areas for steelhead and fall-run Chinook; however, low flows can restrict access to a large portion of these areas (CH2M Hill 2002).

## Rearing Habitat

Rainfall provides most of the natural flow in the Cottonwood Creek watershed, resulting in a hydrology with abrupt swings correlated to storm events; higher flows are in winter and spring, and low flows are in summer and fall (CH2M Hill 2002). In years with low rainfall, both flow and water temperatures can impede escapement and successful recruitment of juvenile salmonids (CH2M Hill 2002). However, the mainstem does have deep pools and riffles to provide cooler holding areas during summer and fall (CH2M Hill 2002). In addition, Cottonwood Creek has an established riparian corridor that is beneficial for juvenile rearing (CH2M Hill 2002).

## Limiting Factors

Low flows in years with limited precipitation can limit the availability of habitat given the flashy nature and limited aquifer recharge within the Cottonwood Creek watershed (CH2M Hill 2002). Other limiting factors include heavy sediment loads, gravel extraction, agricultural practices including the Anderson-Cottonwood Irrigation District canal, timber harvesting, and urban development. One of the recommendations in the Cottonwood Creek Watershed Management Plan is for the Cottonwood Creek Watershed Group (CCWG) to conduct or facilitate a limiting factors analysis to fully evaluate the existing limitations for salmonids (CH2M Hill 2007).

## Monitoring Activities

CDFG staff conducts a snorkel survey on Beegum Creek to estimate the annual spring-run escapement. The survey is conducted three times a year on the North Fork from RM 0.5 to the Highway 36 Bridge. The survey also provides information on the spatial distribution of holding Chinook. CDFG has conducted the survey in most years since 1973. No annual monitoring is of Cottonwood Creek for steelhead.

## Restoration Activities

CCWG was formed in 1999 to "preserve the environment, private property and water rights, and economic resources of the Cottonwood Creek Watershed through responsible stewardship, liaison, cooperation, and education" (CH2M Hill 2007). CH2M Hill, with funding from the State Water Board and CALFED and input from stakeholders, prepared a watershed management plan for the CCWG. The management plan identifies issues in the watershed and establishes goals, objectives, and actions for addressing them.

The watershed management plan identifies issues in four categories: water resources and future development; channel and riparian conditions; fishery, vegetation, and wildlife resources; and fire and fuels management (CH2M Hill 2007). The goals that directly impact salmonids include addressing bank and channel instability, developing a sustainable gravel management program,

sustaining and enhancing native fish populations, sustaining and expanding riparian habitat, sustaining and enhancing water quality, increasing both stormwater infiltration and base flows, and reducing fine-grained sediment discharge into the waterways (CH2M Hill 2007). In part, the watershed management plan recommends that the CCWG should establish both juvenile and adult salmonid monitoring programs, conduct a limiting factors analysis for salmonids, assess the impacts of bank stabilization projects on riparian and aquatic habitats, and implement CALFED ERP targets that are applicable to Cottonwood Creek (CH2M Hill 2007). The ERP targets include maintaining and improving existing habitat and facilitating passage of spring-run and steelhead to holding, spawning, and rearing habitat.

Cottonwood Creek is the third largest tributary on the western side of the Sacramento River basin and the largest undammed watershed in the northern Central Valley (CH2M Hill 2002). The watershed is relatively undeveloped with an active, established, riparian corridor and provides important habitat for spring-run Chinook and steelhead that could be both expanded and enhanced with watershed improvements.

# Battle Creek

## Spawning/ Holding Habitat

Battle Creek is an east-side tributary of the Sacramento River that drains from the southern Cascade Range, with attributes similar to tributaries upstream of Shasta Dam (Kier Associates 1999, Lindley et al. 2007). Large snowfields and spring-fed creeks maintain streamflow until late summer in both the North and South Forks of Battle Creek, providing suitable holding and spawning water temperatures. Spring-run Chinook and steelhead can access approximately 14 miles of spawning and holding habitat in the North fork and approximately 18 miles in South Fork (Kier Associates 1999).

The spawning habitat in the North Fork has high-gradient stream segments, similar to those in Mill and Deer Creeks, upstream of Eagle Canyon Dam and elevations over 2,000 feet occur above North Battle Creek Feeder Dam. On the South Fork, similar high-gradient stream segments exist upstream of Inskip Dam; elevations over 2,000 feet occur upstream of the South Dam (Kier Associates 1999).

The Coleman National Fish Hatchery (CNFH) barrier weir, the CHFH Intake 3 diversion weir, the Orwick Diversion Dam, and the Coleman Powerhouse tailrace are potential passage barriers or impediments on the mainstem (DWR 2005). The fish ladder on the CNFH barrier weir is used during the adult steelhead migration period for broodstock collection; however, since 1996, all naturally spawned adult steelhead are allowed to pass the barrier (Jones & Stokes 2005). Steelhead also can pass over the barrier weir and access the upper watershed during periods of higher flow (>300 cfs) (Kier Associates 1999).

The North Fork has three diversion dams (Wildcat, Eagle Canyon, and North Battle Creek) and the South Fork has three diversion dams (South Diversion, Inskip, and Coleman) that can impede adult migration (DWR 2005). PG&E currently provides minimum flows of 30 cfs under an interim flow agreement to improve passage in both the North and South forks (Kier Associates 1999).

## Rearing Habitat

The Battle Creek Watershed Conservancy developed a set of biologically optimum flows for each reach and month using an IFIM study. The biologically optimum flows that were selected provide at least 95% of the maximum weighted usable area (WUA) for the limiting life history stage *(*Kier Associates 1999). If implemented, these flows would provide sufficient habitat for salmonids rearing in Battle Creek. The current interim flow agreement targets also improve habitat conditions for spring-run and steelhead rearing in part by reducing water temperature in the lower reaches of the watershed.

## Limiting Factors

The primary limiting factors on Battle Creek are associated with hydroelectric and agricultural diversions (Kier Associates 1999). Past hatchery operations also limited passage of spring-run and steelhead into the upper watershed until a disease-free water supply was established in the late 1990s (Kier Associates 1999).

The hydroelectric operations and agricultural diversions affect instream flow, water temperatures, fish passage, entrainment, and gravel supplies. PG&E currently operates five powerhouses; two small storage reservoirs; three forebays; and eight diversions along with a network of approximately 20 canals, ditches, flumes, and pipelines (Kier Associates 1999). In 1995, PG&E agreed to an interim flow agreement to increase flows above the minimum FERC requirements until a more permanent arrangement is reached (Kier Associates 1999).

## Monitoring Activities

Spring-run escapement surveys were conducted from 1946 to 1956 using spawning area surveys and/or redd counts. In the early 1950s, some counts of spring-run Chinook passing CNFH were recorded, and stream surveys were conducted in the early 1960s (Kier Associates 1999). In 1995, USFWS installed a trap on the CNFH barrier weir and installed an underwater video camera to record passage of spring-run Chinook and steelhead. The weir trap is operated daily from March through May, and the underwater video monitoring is conducted from June through July. In 2002, USFWS added jumper video monitoring during daylight hours from August through December. These three monitoring programs provide passage estimates into upper Battle Creek.

In 2001, USFWS standardized the snorkel survey to sample from the mainstem at RM 2.8 up to the confluence, the North Fork up to Eagle Canyon Dam, and the South Fork up to Coleman Diversion Dam. USFWS staff conducts the survey once or twice a month from May until mid-November to identify spawning locations and timing for both spring-run Chinook and steelhead.

Between 2002 and 2006, USFWS also conducted a steelhead redd survey on the mainstem, on the North Fork from the confluence to Eagle Canyon Dam, and on the South Fork from the confluence to Coleman Diversion Dam. The survey is conducted twice a month from November through April to collect data on the number of redds and the spatial and temporal spawning distribution.

## Restoration Activities

Battle Creek offers a unique opportunity to support spring-run and steelhead recovery due to its geological and hydrological features. The proposed Battle Creek Salmon and Steelhead Restoration

Project (Restoration Project) would restore and enhance approximately 42 miles of habitat by modifying hydroelectric operations in a way that minimizes the loss of clean, renewable energy (Jones & Stokes 2005). In 1999 Reclamation, NMFS, USFWS, CDFG, and PG&E signed a memorandum of understanding (MOU) outlining the Restoration Project (Jones & Stokes 2005). Under the MOU, PG&E agreed to forego some energy generation in order to provide instream flows, pursue an amendment to the FERC license, and transfer certain water rights to CDFG (Jones & Stokes 2005). Other actions address flow management, passage, restoration of stream function, diversions, and water routing.

The proposed actions include removing five hydroelectric diversion dams (Wildcat, South, Soap Creek Feeder, Lower Ripley Creek Feeder, and Coleman), installing screens and ladders on three diversion dams (North Battle Creek Feeder, Eagle Canyon, and Inskip), increasing flows, dedicating instream water rights, and eliminating the mixing between the North Fork and South Fork water (Jones & Stokes 2005). The actions are divided into three phases, 1A, 1B, and 2. Funding agreements were reached in July 2008 to provide $49.25 million to implement Phase 1A which focuses on the North Fork (Marshall 2008). In Phase 1A, fish screens and ladders will be installed on Battle Creek Feeder and Eagle Canyon Dams, Wildcat Diversion Dam and appurtenant conveyance systems will be removed, the Eagle Canyon Canal pipeline will be installed, and Asbury Dam will be modified (Marshall 2008).

Phase 1B involves installing a tailrace connector and bypass at Inskip Powerhouse; funding is being actively pursued. Potential funding for Phase 2 has not been identified. Phase 2 includes installing a fish screen and ladder on Inskip Dam, installing a tailrace connector at South Powerhouse, and removing several diversion dams and appurtenant conveyance systems on the South Fork.

The Restoration Project will allow Chinook salmon and steelhead to access prime habitat from the confluence with the Sacramento River to the natural barriers above the hydroelectric dams as they did historically (Jones & Stokes 2005).

# Thomes Creek

## Spawning/ Holding Habitat

Historically, spring-run Chinook were observed sporadically in Thomes Creek, but the intermittent nature of the flow in this tributary limits the use by spring-run Chinook for spawning and holding. Steelhead can use Thomes Creek for spawning in years with adequate streamflows (Vestra 2006). CDFG identified a low-elevation impassable barrier immediately above the confluence with Horse Trough Creek that limits the amount of spawning and holding habitat for both spring-run and steelhead (Vestra 2006).

## Rearing Habitat

Thomes Creek has potential for non-natal rearing of spring-run juveniles in years with adequate flow (Vestra 2006). Juvenile steelhead rearing is limited in Thomes Creek due to the reduced streamflows in years with below-normal precipitation. There is potential for natal and non-natal steelhead rearing in some years when suitable conditions exist (Vesta 2006).

### Limiting Factors

Low flows in Thomes Creek are the major limiting factor for both spring-run and steelhead. Spring-run and steelhead production also is limited by high water temperature, lack of holding pools, erosion, and gravel mining (CH2M Hill 1998). Potential entrainment of juvenile salmonids by two seasonal diversions dams also may contribute to reduced production (Vestra 2006).

### Monitoring Activities

No annual monitoring is conducted on Thomes Creek for spring-run Chinook or steelhead.

### Restoration Activities

In 2007, the Tehama County RCD prepared a bi-annual report outlining their management actions from July 2005 through June 2007 to improve the Tehama West Watershed (TCRCD 2007). The report focused on actions in two areas, land use and planning and watershed management and health. The actions included completing the Tehama West Watershed Assessment and development of the Tehama West Watershed Management Plan (TCRCD 2007). The draft management plan that was released in August 2008 outlines actions to protect and enhance fall-run Chinook and steelhead populations in Thomes Creek (TCRCD 2008). These actions would benefit any spring-run that use Thomes Creek in wet years. However, the intermittent flow characteristics limit establishment of self-sustaining populations of spring-run Chinook or steelhead in Thomes Creek (Vestra 2006).

## Stony Creek

### Spawning/ Holding Habitat

Historically, spring-run Chinook spawning occurred upstream of the Stony Gorge Dam, which was built in 1928 (CH2M Hill 1998). Downstream of Stony Gorge, Black Butte Dam is a total barrier to salmonid migration (USFWS 1995). Fall-run Chinook have been documented spawning 6 miles downstream of Black Butte Dam at the North Diversion Dam, but no spring-run have been observed spawning in that area. The North Diversion Dam is a migration barrier to fall-run Chinook under most flow conditions (CH2M Hill 1998). Because of an impassable barrier at the Glenn-Colusa Irrigation District (GCID) canal at RM 3, an underground siphon was installed in 1999 (H. T. Harvey & Associates et al. 2007a). No passage studies have been conducted at the siphon site.

Steelhead spawning is possible in some years in Stony Creek and is used opportunistically when attraction flows are present (H.T. Harvey & Associates et al. 2007b). Gravel recruitment is limited due to entrapment behind Black Butte Dam, thus reducing the amount of useable spawning habitat for steelhead. Low flows may be a passage barrier for steelhead in years with below-normal precipitation.

### Rearing Habitat

Non-natal spring-run Chinook and steelhead rearing has been documented in Stony Creek, but stranding and entrainment is known to occur due to operation of the Tehama-Colusa canal and the GCID canal (CH2M Hill 1998). Low flows and high water temperatures limit the amount of rearing habitat in Stony Creek in some years (H.T. Harvey & Associates et al. 2007b).

## Limiting Factors

Migration barriers, low flows, high water temperatures, limited spawning habitat, and poor water quality limit salmonid production in Stony Creek (CH2M Hill 1998). Entrainment and standing caused by operations of the Tehama-Colusa canal and the GCID canal affect both juvenile rearing and adult escapement to Stony Creek (CH2M Hill 1998). Streambank erosion, loss of riparian habitat, and gravel mining also limit salmonid production (H. T. Harvey & Associates 2007b).

## Monitoring Activities

No annual monitoring is conducted on Stony Creek for spring-run Chinook or steelhead.

## Restoration Activities

Stony Creek is the second largest west-side tributary of the Sacramento River; it has undergone substantial geomorphic change, channel instability, and degradation of native riparian plant communities (H.T. Harvey & Associates 2007b). Historically, Stony Creek was a flashy, episodic channel; because of dam operations and extensive gravel mining, the creek now meanders within an artificially narrow channel causing both bed and bank erosion (H.T. Harvey & Associates 2007b).

In 2004, the Glenn County RCD organized a Landowner Advisory Committee and a Technical Advisory Committee to help with implementing projects in the Lower Stony Creek Watershed (GCRCD 2008). The Stony Creek Watershed Assessment was completed in 2007, and work began on the Lower Stony Creek Watershed Restoration Plan (GCRCD 2008). The Glenn County RCD also established a demonstration site for invasive plant removal and bank stabilization, and implemented a monitoring program (GCRCD 2008). An adopted long-range plan set goals related to water resources, loss of agricultural land and urban encroachment, range management, weed control, and loss of habitat (GCRCD 2006).

The natural recruitment of native riparian seedlings suggests that the hydrological conditions needed to support a riparian corridor already exist in lower Stony Creek (H. T. & Associates et al. 2007a). Although the low elevation, lack of holding pools, low flows, and high water temperatures make Lower Stony Creek unsuitable for spring-run Chinook, restoration efforts could benefit both fall-run Chinook and steelhead.

# Antelope Creek

## Spawning/ Holding Habitat

The Antelope Creek watershed is relatively long and narrow, with moderate to steep slopes, and is located within the southernmost extension of the Cascade Range (Armentrout et al. 1998). The watershed is similar to both Mill and Deer Creeks, which support self-sustaining runs of spring-run Chinook salmon and steelhead.

Spring-run have access to approximately 9 miles of spawning and holding habitat in Antelope Creek, starting from approximately 1.6 miles downstream of Paynes Creek crossing to McClure Place on the North Fork and Buck's Flat on the South Fork (CDFG 1966, Airola 1983 as reported in Armentrout et al. 1998). Paynes Creek crossing also is referred to as Tehama Wildlife Area Crossing.

Armentrout et al. (1998) used results from the U.S. Forest Service Fisheries Habitat Assessment to determine the number of holding pools present in Antelope Creek. Holding pools were defined as pools greater than 6 feet deep. In Antelope Creek, seven holding pools on the mainstem represent 54% of all pools, six holding pools on the South Fork represent 26% of all pools, and no holding pools are on the North Fork (Armentrout et al. 1998).

Very little information on steelhead distribution and abundance is available for Antelope Creek; however, they probably use the same spawning areas as spring-run Chinook and may have access to habitats beyond what is known for salmon (Armentrout et al. 1998).

## Rearing Habitat

The high habitat diversity of Antelope Creek helps support juvenile salmonid rearing (Armentrout et al. 1998). In addition, the deep pools, cool water springs, vegetative shading, and natural diurnal fluctuations in water temperature offset the potential effects of increased water temperature during summer and early fall, supporting the yearling life history stage for both spring-run Chinook and steelhead (Armentrout et al. 1998).

## Limiting Factors

Water temperature, low flows, agricultural diversions, loss of natural river morphology, limited spawning habitat, fine sediments, water quality, loss of riparian habitat, and harvest/angling affect salmonid production in Antelope Creek (NMFS 2008). Low flows in the valley portion due to springtime agricultural diversions are the largest limiting factor for spring-run production in Antelope Creek. Low flows also can impede access to Antelope Creek by reducing attraction flows, creating passage issues at agricultural barriers, and increasing water temperatures for holding and spawning salmonids (NMFS 2008).

## Monitoring Activities

In 1989, CDFG began conducting snorkel surveys on various stretches of the creek. In 1992, CDFG standardized the snorkel survey methods and has conducted an annual survey during the fourth week of July to estimate the spring-run population. The survey also provides data on the distribution of holding Chinook. Staff surveys the North Fork from the confluence to McClure Place and the South Fork from the confluence to SF Gun Club. No annual monitoring is conducted on Antelope Creek for steelhead.

## Restoration Activities

Tehama County RCD is currently preparing a watershed assessment for both Paynes Creek and Antelope Creek. Tehama County RCD will use the information from the assessment to develop the Tehama Eastside Watershed Plan.

Antelope Creek is one of few remaining tributary streams where salmonids have access to the historical headwater stream habitat with a natural hydrograph in the upper watershed (Armentrout et al. 1998). Historically, Antelope Creek was estimated to support 500 spring-run Chinook and 300 steelhead (CH2M Hill 1998). Due to the steep sides of the canyon, human land use impacts are mostly limited to the valley floor portion of the watershed. These factors make Antelope Creek a promising area for expansion and enhancement of spring-run Chinook and steelhead habitat.

# Mill Creek

## Spawning/ Holding Habitat

Mill Creek is a long, narrow watershed; most of the watershed is bordered by Lassen National Forest (CH2M Hill 1998). Because the upper watershed is relatively inaccessible, it is undisturbed, pristine, salmonid spawning habitat (CH2M Hill 1998). No significant water storage impoundments in the watershed allow for a natural hydrograph that is supported by both seasonal rainfall and snowmelt (CH2M Hill 1998). Mill Creek supports an independent, self-sustaining spring run and provides the highest elevation spawning habitat known in California (CH2M Hill 1998).

Spring-run holding pools exist in the upper canyon areas, and spawning occurs between Little Mill Creek confluence and the Highway 36 Bridge (CH2M Hill 1998). Armentrout et al. (1998) noted that the amount of holding habitat is limited in the upper 7.6 miles of Mill Creek and that holding habitat was more abundant in the section below the Mill Creek Campground. There are 20 holding pools out of 86 pools in the 13 miles of stream that were surveyed downstream of the campground (Armentrout et al. 1998). The amount of holding habitat just below this reach is unknown because it could not be accessed for the survey, but spring-run were previously observed holding in this area (Armentrout et al. 1998).

Mill Creek has higher sediment loading than Antelope or Deer Creeks; however, it does not appear to limit spring-run salmon from spawning. It may impact redds after flood events that redistribute the fines during the incubation period (Armentrout 1998). Low flows in the lower portion of the watershed can impede upstream passage of adult salmonids in some years (CH2M Hill 1998). No physical passage barrier limits upstream migration on Mill Creek; however, the combined effect of higher stream gradients, lower streamflows, and habitat availability sets the upper limit for migration in the headwater reaches (Armentrout et al. 1998).

Very little distribution and abundance data on steelhead spawning are available in Mill Creek, but their range is expected to include the range for spring-run and can extend beyond it (Armentrout et al. 1998).

Historically, Clough Dam, Ward Dam, and Upper Diversion Dam impeded the upstream passage of salmonids under low-flow conditions. Clough Dam was removed in 2003, and Ward Dam was modified in 1997 to improve upstream passage (DWR 2005). In recent years, streamflows have been augmented through a water exchange program to improve upstream passage for spring-run Chinook (DWR 2005).

## Rearing Habitat

The upper watershed substrate composition and pools provide a high level of habitat diversity and overwintering cover that supports juvenile salmonid rearing (Armentrout et al. 1998). This portion of the creek is relatively undisturbed by human land use and provides relatively pristine rearing conditions. Water temperatures remain low during the spring-run rearing period and support a stream-type life history. The proportion of fry that remains in the creek to migrate as yearlings varies annually, depending on stream conditions (Harvey-Arrison pers. comm.). The lower portion of Mill Creek also provides good rearing habitat although low flows due to diversions can increase water temperature and impede juvenile migration from the creek (DWR 2005).

## Limiting Factors

The Mill Creek watershed is relatively undisturbed with a natural flow regime; however water diversions in the lower portion of the creek can increase water temperatures and impede adult passage upstream and juvenile passage downstream.

## Monitoring Activities

CDFG staff has monitored spring-run escapement on Mill Creek since 1947 using spawning area surveys and/or aerial redd counts (1947–1953), ladder counts (1954–1964 and 1986–1987), area surveys (1971–1985), electronic fish counters (1988–1996), carcass surveys, and redd surveys. Since 1997, CDFG staff has conducted a single redd survey at the peak of the spawning period to estimate the annual spring-run spawning population. The survey takes place between October 1 and October 15 from the Lassen National Park boundary to the confluence of Little Mill Creek. Staff collects data on the number of complete redds and the number, age class, and sex of carcasses. The survey also provides information on the spatial spawning distribution and population trends over time.

CDFG staff also conducted a hydroacoustic pilot study in 2006 to evaluate the use of two different hydroacoustic methods, Biosonics split-beam sonar and the dual-frequency identification sonar (DIDSON), to estimate spring-run escapement to Mill Creek at Sherwood Bridge (Creek Mile 2.0). CDFG found the DIDSON system to be more effective because it samples a great volume and detects targets across a broader range of flows and water levels (Johnson et al. 2006). No annual monitoring is conducted for steelhead on Mill Creek.

## Restoration Activities

Mill Creek was identified as a priority stream in the USFWS-AFRP Final Restoration Plan (USFWS 2001). In the Restoration Plan, USFWS identified four actions to help increase the natural production of anadromous fish in Mill Creek: (1) continue providing instream flows to facilitate adult and juvenile salmonid passage; (2) develop a watershed strategy to preserve habitat productivity; (3) improve spawning habitat in lower Mill Creek for fall-run Chinook; and (4) establish, restore, and maintain riparian habitat in lower Mill Creek. To date, AFRP has spent approximately $1,000,000 on restoration projects in Mill Creek (AFRP website).

There are four ongoing watershed projects: (1) the Lower Mill Creek Riparian Restoration Project, (2) the Deer and Mill Creek Watershed Project; (3) the Deer, Mill, and Antelope Creek Stabilization Project; and (4) the Mill Creek Water Exchange Program (DWR 2005). The objective of the Lower Mill Creek Riparian Restoration Project is to maintain and restore riparian habitat in the lower reaches; the project is funded through the Mill Creek Conservancy and The Nature Conservancy (DWR 2005). The Deer and Mill Creek Watershed Project develops and coordinates resource plans to benefit spring-run Chinook and is funded by the State Water Board (DWR 2005). A final Mill Creek Watershed Management Strategy Report was completed in 1997. The Stabilization Project is funded by CALFED to reduce inputs of fine sediments from road-related sources (DWR 2005). The Mill Creek Water Exchange Program is discussed in more detail below.

Historically, Clough Dam fish ladder was considered ineffective in passing salmonids under low-flow conditions (Armentrout et al. 1998). DWR removed the dam and installed an inverted siphon pipe to move the diverted water to the Upper Diversion Dam under a contract awarded by the California

Bay-Delta Authority (DWR 2005). Clough Dam was removed in 2002, and the entire project was finished in 2003 (DWR 2005).

The two diversion dams on Mill Creek, Ward Dam and Upper Diversion Dam, can impede the upstream migration of spring-run due to reductions in streamflow (DWR 2005). CDFG constructed a new modified pool and chute ladder on Ward Dam in 1997 improving upstream passage under lower flow conditions (DWR 2005). A new fish screen also was installed at the Upper Diversion Dam in 2000 to reduce entrainment of juvenile salmonids (DWR 2005).

Streamflows at the diversion dams are augmented through a Water Exchange Program Agreement between CDFG, DWR, and Los Molinos Mutual Water Company (LMMWC) to improve both upstream and downstream passage of salmonids (DWR 2005). The program exchanges instream water for groundwater where landowners forego diversions of up to 16 cfs when additional flows are needed. The Mill Creek Conservancy conducted a study starting in 2004 to investigate and develop a long-term or permanent water management program on Mill Creek (DWR 2005).

Mill Creek, like Antelope Creek, is one of few remaining tributaries streams where salmonids have access to the historical headwater stream habitat with a natural hydrograph in the upper watershed (Armentrout et al. 1998). Past escapement estimates indicate that Mill Creek could support up to 3,500 spring-run Chinook and 2,000 steelhead (CH2M Hill 1998). Due to the steep sides of the canyon, human land use impacts are mostly limited to the valley floor portion of the watershed. AFRP and other organizations recognized the importance of Mill Creek for spring-run Chinook and have funded numerous restoration projects over the last 10 years.

# Deer Creek

## Spawning/ Holding Habitat

Unlike most tributaries in the Sacramento River basin, salmonids can still access the headwater stream habitat because there are no impoundments in Deer Creek (Armentrout et al. 1998). Deer Creek currently supports a self-sustaining population of spring-run Chinook (Lindley et al. 2007). Like Mill and Antelope Creeks, Deer Creek has excellent instream habitat conditions for spring-run Chinook holding, spawning, and rearing (Armentrout and other 1998). Deer Creek is in a long, narrow watershed with moderate to steep slopes. It has approximately 25 miles of spring-run holding habitat from Upper Falls downstream to the confluence with Rock Creek, but most holding occurs in the first 15.5 miles above Ponderosa Way (Armentrout et al. 1998). Based on a survey of the upper 17 miles of the holding habitat, Armentrout et al. (1998) noted the presence of 166 pools—of which 60% where classified as holding pools (depth > 6 feet).

Spring-run spawning extends from Upper Falls downstream nearly 30 miles, but the distribution of spawning can vary based on water temperatures and the amount of runoff (Armentrout et al. 1998). Based on visual observations, Armentrout et al. (1998) noted that the spawning substrate is in good condition with a low amount of fine sediment.

Very little distribution and abundance data are available on steelhead spawning in Deer Creek, but their range is expected to include the range for spring-run and can extend beyond it (Armentrout et al. 1998). Steelhead have access to an additional 13 miles of habitat when the fish ladder at Upper Falls is opened in fall (DWR 2005).

## Rearing Habitat

The habitat diversity is high in Deer Creek and provides an abundance of microhabitats to support the needs of juvenile salmonids during their stream residency (Armentrout et al. 1998). Deer Creek also provides the cobble and gravel substrates with open interstitial spaces necessary for overwintering juvenile spring-run Chinook and steelhead (Armentrout et al. 1998). Like Mill Creek, Deer Creek supports a stream-type life history, with a varying proportion of spring-run remaining in the creek and migrating as yearlings. Rearing and outmigration in the lower portion of the Creek has improved after all the diversions were screened to prevent entrainment (Harvey 1997).

## Limiting Factors

Water diversions on the valley floor of the creek are physical barriers and reduce springtime flows, which can delay adult spring-run migration into the creek and impact outmigration of juvenile spring-run and steelhead. The five diversions are Stanford-Vina Ranch Diversion Dam, Cone-Kimball Diversion Dam, North Main Diversion Canal, Deer Creek Irrigation Dam, and an unnamed canal on Deer Creek (DWR 2005). The low flows also increase water temperatures in the lower portion of the creek, limiting juvenile rearing in the Valley reach.

The upper watershed is inaccessible for most of its length due to the steep canyon walls, except where Highway 32 parallels the creek, limiting human use. However, the unstable sloughing of soil on the canyon shelves due to roads, landings, and skid trails can affect water quality (DWR 2005). Fishing for spring-run on a catch-and-release basis (with gear restrictions) is permitted from the end of April until November 15 (NMFS 2008). The impacts of fishing on the holding and spawning adults have not been documented, but some inadvertent negative impacts due to anglers disturbing redds are possible (NMFS 2008).

Deer Creek provides relatively good rearing habitat for juvenile salmonids; but flood control activities have reduced channel diversity, riparian habitat, instream cover, and floodplain habitat (NMFS 2008). All of the water diversions have fish screens to reduce mortality, but low flows can impede fish passage (DWR 2005).

## Monitoring Activities

CDFG has monitored spring-run escapement in Deer Creek since 1940 using partial weir and ladder counts (1940–1948), spawning area surveys and/or aerial redd counts (1948–1956), electronic fish counters (1963–1964), area surveys (1970–1986), carcass surveys, and snorkel surveys (1987–1991). Since 1992, CDFG staff has conducted a standardized snorkel survey to estimate the annual spawning population by making a single pass during the first week of August between Upper Deer Creek Falls and Dillon Cove. CDFG collects data on the number of salmon observed and the spatial distribution. No annual monitoring is conducted for steelhead on Deer Creek.

## Restoration Activities

In 1999, USFWS prepared a draft Programmatic Environmental Assessment of anadromous fish restoration actions in Lower Deer Creek (USFWS 1999). The proposed actions were divided into 10 categories: (1) land conservation; (2) fish screens; (3) fish passage; (4) channel and instream habitat modifications; (5) spawning gravel replenishment; (6) streambank modification; (7) riparian

revegetation; (8) meander belt and floodplain management; (9) agricultural management; and (10) road management.

Deer Creek was identified as a priority stream in the AFRP Final Restoration Plan (USFWS 2001). In the Restoration Plan, USFWS identified five actions to help increase the natural production of anadromous fish in Deer Creek: (1) acquire water from willing sellers to supplement instream flows in the lower 10 miles of Deer Creek; (2) develop a watershed management plan; (3) improve spawning habitat in lower Deer Creek for fall and late-fall-run Chinook; (4) restore and preserve riparian habitats along Deer Creek; and (5) plan and coordinate flood management activities with least damage to fishery resources and riparian habitat.

AFRP has funded several projects in Deer Creek to protect riparian habitat and reduce erosion. Two projects focused on protecting the riparian corridor in the lower Deer Creek watershed. In 1997, 2.5 miles of riparian corridor was acquired resulting in the protection of 468 acres of riparian habitat; another project, completed in 2004, fenced off two sections of streambank to protect a Nature Conservancy conservation easement (DWR 2005). In addition, an erosion control project was undertaken to identify the highest erosion sites in the Upper Meadows area of Deer Creek and offered engineered solutions to some specific sites (CSUC 2001a).

In August 2007, the Deer Creek Irrigation District (DCID) entered into a long-term agreement with DWR and CDFG to construct, operate, maintain, and monitor a flow enhancement program on lower Deer Creek in order to improve passage for both adult spring-run and juvenile salmonids. The Deer Creek Flow Enhancement Program provides DCID with a supplemental agricultural water supply so that surface water can remain in the creek when needed in spring and early fall to support fish passage. The supplemental supply includes water acquired from new groundwater wells, efficiency improvements to DCID's distribution system, and new water management techniques (DCID et al. 2005). Operation of the program incorporates adaptive management and a comprehensive monitoring program, and fulfills the groundwater protection requirements in the Tehama County AB 3030 Groundwater Management Plan (DCID et al. 2005).

The instream flows are augmented when the flows below the Stanford-Vina Diversion Dam are measured at less than or equal to 50 cfs between April 1 and June 30, and again between October 15 and November 15 (DCID 2008). In that case, DCID bypasses up to 10 cfs of surface water in Deer Creek. CDFG also can request DCID to bypass up to 30 cfs for 1 or 2 consecutive days in order to generate a pulse flow to attract migrating adults (DCID 2008). As part of the agreement, CDFG will conduct a Fish Passage Management Assessment Program to evaluate the effectiveness of the flow actions (DCID 2008). In addition to the Flow Enhancement Program, DWR is working with DCID to improve fish passage at the DCID Diversion Dam (DWR website). DWR is currently developing a detailed topographic survey of the area and will conduct a preliminary engineering investigation (DWR website).

The Stanford-Vina Ranch Irrigation Company (SVRIC) has improved its fish ladder on the Stanford-Vina Ranch Diversion Dam and constructed a holding pool downstream of the dam to improve adult passage (DWR 2005). The SVRIC also has voluntarily bypassed instream flow upon request by CDFG to augment flows during critical migration periods for anadromous salmonids (DWR 2005).

Further downstream, the Deer Creek Watershed Conservancy (DCWC) is working on a Lower Deer Creek Restoration and Flood Management Feasibility Study with funding from the CALFED ERP (Tompkins et al. 2007). The project is intended to implement flood management actions that

provide flood flow conveyance while improving ecosystem health and function (Tompkins et al. 2007). The project includes baseline monitoring, a feasibility study, identifying project elements, conceptual design of those elements, environmental documentation, implementation, monitoring, and adaptive management. As part of the study, Mussetter Engineering et al. (2007) identified two sets of alternatives—one that involves actions downstream of Highway 99 and another that involves actions upstream of Highway 99, two hydraulically disconnected reaches.

Deer Creek, like Antelope and Mill Creeks, is one of few remaining tributaries streams where salmonids have access to the historical headwater stream habitat with a natural hydrograph in the upper watershed (Armentrout et al. 1998). The average natural production has been estimated at 3,260 spring-run Chinook and approximately 1,000 steelhead (CH2M Hill 1998). Due to the steep sides of the canyon, human land use impacts are mostly limited to the valley floor portion of the watershed. Similar to Mill Creek, AFRP and other organizations recognized the importance of Deer Creek for spring-run Chinook and have funded numerous restoration projects over the last 10 years.

# Butte Creek

## Spawning/ Holding Habitat

Butte Creek currently supports an independent, self-sustaining spring-run Chinook population (Lindley et al. 2007). This population is also the largest remaining population in the Central Valley. Near the headwaters, several small tributaries converge in the Butte Meadows basin then Butte Creek flows through a steep canyon approximately 25 miles in length where it drops into the valley floor near the city of Chico (BCWP 1998). Approximately 6 miles downstream of the Butte Meadows is the first major diversion dam, the Butte Creek Diversion Dam (also referred to as the Butte Creek Head Dam). Downstream of the Butte Creek Diversion Dam is a section with several large waterfalls that is “pool-drop” in nature and is believed to restrict upstream salmonid migration except during periods of extremely high flows (BCWP 1998). Butte Creek continues downstream to the DeSabla Powerhouse where the creek is commingled with water from the West Branch of the Feather River (PG&E 2007b). Just downstream of the DeSabla Powerhouse, Butte Creek is diverted at the Centerville Diversion Dam, which is considered the upper limit for salmonid migration (PG&E 2007b).

During summer, spring-run Chinook use holding pools between a natural barrier (known as the Quartz Bowl) about 1 mile below Centerville Diversion Dam and the Honey Run Covered Bridge, a distance of about 10 miles (BCWP 1998). Most of the spawning occurs in this area, but spring-run also move further downstream near the Parrot-Phelan Diversion (BCWP 1998). In years with higher flows, both spatial and temporal overlap in spawning of fall and spring-run Chinook can occur; in most years, fall-run spawning occurs downstream of the Parrot-Phelan Diversion (CH2M Hill 1998). Imported water from the Feather River may encourage straying by Feather River Hatchery spring-run Chinook into Butte Creek.

Historically, steelhead may have accessed the Butte Meadows, but spawning is now restricted to the area between the Centerville Diversion Dam and Parrot-Phelan Diversion on the mainstem and to tributaries such as Dry Creek, except during periods of extremely high flows (BCWP 1998).

## Rearing Habitat

Because spawning occurs at a much lower elevation in Butte Creek compared to Mill and Deer Creeks, the spring-run exhibit more of an ocean-type life history. Most of the fry migrate out of the creek upon emergence while a smaller fraction migrates as juveniles in spring (BCWP 1998). A few spring-run remain and migrate as yearlings the following fall. Steelhead and the remaining spring-run rear below Centerville Diversion Dam where summer flows are generally high enough to keep water temperature below 68 °F (BCWP 1998). The fry that migrate upon emergence use both the lower portion of Butte Creek and the Sutter Bypass for rearing prior to emigration in the late spring (BCWP 1998).

## Limiting Factors

Fish passage is a major factor affecting both adult and juvenile salmonids in Butte Creek. Starting from the Sutter Bypass, adult salmonid passage is affected by about 22 major structures—including agricultural diversions, hydroelectric dams, and flood bypasses (DWR 2005). Low flows and the associated increased water temperatures can be problematic for all life stages of salmonids within Butte Creek. Water quality is generally good in the upper watershed, but dissolved oxygen concentrations and water temperatures are the primary water quality issues in the lower portion of Butte Creek (DWR 2005). Agricultural and flood management practices have altered the natural stream processes, reducing the amount of riparian habitat in Butte Creek (DWR 2005). Beneficial uses that can impact salmonid habitat include gravel extraction, mining, recreation, water diversions for waterfowl habitat, and timber harvest (DWR 2005).

## Monitoring Activities

Since 1995, CDFG staff has conducted a snorkel survey on Butte Creek in July—from the Quartz Bowl to the Covered Bridge—to estimate the annual escapement of spring-run Chinook and steelhead. CDFG collects data on the number of spawners, age distribution, and spatial distribution. From 1954 to 1990, CDFG estimated spring-run escapement based on expansions from an annual carcass, redd, and live salmon counts survey. In 1991, CDFG switched to the snorkel survey; and the methods were standardized in 1995. PG&E also conducted a snorkel survey in Butte Creek from 1981 to 1994.

Since 1995, CDFG staff also has conducted a carcass survey to estimate spring-run escapement. The survey is conducted between June 15 and December 31 each year between the Quartz Bowl and the Western Canal Siphon. CDFG uses the survey to calculate the annual spring-run escapement along with an estimate of pre-spawn mortality, spatial and temporal distribution, and size and age composition.

## Restoration Activities

Formation of the Butte Creek Watershed Conservancy (BCWC) in 1995 brought together landowners; water users; recreational users; conservation groups; and local, state, and federal agencies to protect, restore, and enhance the Butte Creek watershed (BCWC 2000). BCWC enlisted the services of California State University (CSU), Chico to prepare an Existing Conditions Report that was completed in 1998. The Existing Conditions Report was used to support BCWC in preparing a Watershed Management Strategy that was completed in 2000. The Watershed Management

Strategy outlines a series of goals and objectives to provide an adaptive management framework and a list of potential projects and actions (BCWC 2000).

The goals and objectives addressed issues related to education and outreach, recreation, fisheries, fuel load, timber management, road erosion, groundwater and water supply, water quality, and flooding (BCWC 2000). For fisheries, the goal was to help enhance and maintain the native fishery—with emphasis on salmon and steelhead. The objectives included supporting efforts to improve passage; protect and enhance existing riparian habitat by providing outreach, assistance, and incentives to willing landowners; maintain and improve water quality through monitoring and encouraging implementation of best management practices (BCWC 2000). Since then, BCWC has worked on projects to improve fish passage, provided facilities for community cleanups, and supported educational programs within the watershed. Currently, BCWC is completing the education and outreach portions of two grants, the CALFED Rural Roads Grant and the Butte Creek Groundwater Modeling Grant (BCWC website).

Butte Creek was identified as a priority stream in the AFRP Final Restoration Plan (USFWS 2001). In the Restoration Plan, USFWS identified 14 high-priority and 27 medium-priority actions to help increase the natural production of anadromous fish in Butte Creek. The priority actions addressed increasing instream flow, passage and screens at diversions, removing dams, developing a watershed management plan, establishing operational criteria, and evaluating juvenile spring-run Chinook life history (USFWS 2001). Since 2001, AFRP has provided approximately $2.5 million towards these restoration actions (AFRP website).

Western Canal District involvement in restoration actions to improve passage in the middle reaches of the mainstem of Butte Creek has resulted in removal of five diversion dams: the Western Canal Main Dam, Western Canal East Channel Dam, Point Four Dam, McGowan Dam, and McPherrin Dam (DWR 2005).

CDFG worked with landowners and other agencies to improve passage in Butte Creek, including installing a new fish screen and a pool and chute ladder at the Parrot-Phelan Diversion Dam (DWR 2005). CDFG is conducting a multi-year study on juvenile spring-run Chinook life history and manages a 285-acre Ecological Preserve along Butte Creek. In 1998, with funding from USFWS, National Fish and Wildlife Foundation, CALFED, and the Wildlife Conservation Board, the CSU, Chico Research Foundation purchased a 93-acre parcel now known as the Butte Creek Ecological Preserve Honey Run unit. The unit is adjacent to the CDFG Butte Creek Canyon Ecological Reserve (CSUC 2001b). The management goals for the Honey Run unit are restoring, protecting, and enhancing habitat for spring-run Chinook and steelhead; improving riparian habitat; and creating a living laboratory and field classroom (CSUC 2001b).

DWR engineered three fish ladders and screen designs. The ladders and screens were constructed in 1997 at Durham Mutual, Adams, and Gorrill Diversion Dams (DWR 2005). In 1999, the Sanborn Slough/Butte Creek Bifurcation Structure was modified to improve flow and fish passage. DWR also is working with Ducks Unlimited and various consulting firms on the multi-faceted Lower Butte Creek Project (DWR 2005). As part of the Lower Butte Creek Project, the Sutter Bypass East Borrow Canal Water Control Structures Project modifies Weir No. 2 and the Willow Slough Weir, including replacing existing fish ladders to improve passage (DWR website).

PG&E is in the process of relicensing the DeSabla-Centerville Project, FERC Project No. 803, with FERC. The current license expires in October 2009. PG&E is proposing to continue operating the

project with no changes to the generation facilities but will adopt resource management measures, remove five stream diversions that are no longer used, and rebuild or refurbish the Centerville Powerhouse (PG&E 2007b). Since 1999, PG&E has worked with CDFG, NMFS, and USFWS to develop an Annual Operations and Maintenance Plan to enhance and protect spring-run Chinook habitat each summer. PG&E releases water from Round Valley and Philbrook Reservoirs to provide additional cool water for spring-run holding from June until mid-September each year (PG&E 2007b). In addition, PG&E increased flows below Lower Centerville Diversion Dam to 60 cfs from late September through February in 2004 to increase spring-run spawning habitat (PG&E 2007b). In following years, PG&E has increased the instream flows from 60 to 75 cfs. In the FERC license application, PG&E proposed additional changes to the minimum instreamflow releases below Lower Centerville Dam based on water-year type in order to continue maximizing the cool water benefits for spring-run Chinook holding, spawning, and rearing (Table B-2).

**Table B-2** Proposed Minimum Instream Flows below Lower Centerville Diversion Dam According to Water-Year Type

| Months | Normal Water-Year Type Minimum Instream Flows | Dry Water-Year Type Minimum Instream Flows |
|---|---|---|
| Sep 15 – Jan 31 | 75 cfs | 60 cfs |
| Feb 1 – Apr 30 | 80 cfs | 75 cfs |
| May 1 – May 31 | 80 cfs | 65 cfs |
| Jun 1 – Sep 14 | 40 cfs | 40 cfs |

Source: Pacific Gas and Electric Company. 2007. DeSabla-Centerville Project: license application. FERC Project No. 803. October. San Francisco, CA.

The spring-run Chinook population in Butte Creek has increased in the last 10 years in part due to the restoration activities taking place (Figure B-2). Due to the low elevation of the watershed, years with below-normal precipitation water temperatures can limit spring-run salmon production. High levels of pre-spawn mortality can occur in years when summer water temperatures exceed the tolerance of holding spring-run Chinook. High summer water temperatures also can affect salmonid rearing within Butte Creek. Recent and ongoing improvements in the Sutter Bypass, however, are providing additional salmonid rearing habitat.

# Big Chico Creek

## Spawning/ Holding Habitat

Historically, Big Chico Creek supported a small run (up to 1,000 fish) of spring-run Chinook, but a viable population is no longer believed to exist (CH2M Hill 1998). Spring-run Chinook have been observed in low numbers in recent years, and water temperatures below Iron Canyon often exceed their tolerance during the summer holding and egg incubation period. Spring-run summer holding and spawning habitat is limited to a 9-mile stretch between Iron Canyon and Higgin's Hole in the foothill reach of Big Chico Creek (BCCWA date unknown). Although passage through Iron Canyon Fish Ladder can be impeded in low-flow years, the habitat in this upper portion of the watershed is relatively pristine (CH2M Hill 1998).

Steelhead also use Big Chico Creek, and spawning occurs in the foothill reach (BCCWA date unknown). Steelhead distribution data are limited due to a lack of species-specific monitoring. Historically, steelhead were observed in Big Chico Creek, and their presence has been detected in recent monitoring by CDFG.

## Rearing Habitat

Both the foothill reach, between Higgin's Hole and Iron Canyon, and the valley reach provide salmonid rearing habitat (BCCWA unknown date). Conditions in the foothill reach are suitable for the year-round rearing necessary for steelhead (BCCWA unknown date). Rearing also occurs in Mud and Rock Creeks although habitat in these creeks has been degraded by flood control measures leading to high water temperatures in most years (CH2M Hill 1998).

## Limiting Factors

Low flows and high water temperatures are the most limiting factors in Big Chico Creek for spring-run and steelhead. Low flows affect passage for both adults and juveniles. Loss of riparian habitat in the valley reach and diversion by flood control structures also limit salmonid production (BCCWA 2006).

## Monitoring Activities

CDFG staff conducts a single snorkel survey on Big Chico Creek each July to estimate the annual escapement of spring-run Chinook and steelhead. CDFG collects data on the number of spawners, age distribution, and spatial distribution. From 1956 to 1985, CDFG estimated spring-run Chinook escapement based on expansions from observational surveys. In 1989, CDFG switched to the snorkel survey; and the methods were standardized in 1995.

## Restoration Activities

The Big Chico Creek Watershed Alliance adopted a Watershed Management Strategy in 2006 (BCCWA 2006). The management strategy identifies goals, objectives, and potential actions to protect and enhance both the ecological integrity and economic vitality of the watershed. Several goals related to salmonids include restoring water quality, restoring sustainable populations of native fish, restoring functioning riparian habitat, and eradicating non-native plant species.

Some of the specific actions include reducing agricultural and urban runoff, reducing stream temperatures, improving the Iron Canyon Fish Ladder, improving passage at diversion dams and culverts, enhancing rearing habitat, restoring floodplain and riparian habitats, and eradicating non-native plant species and replanting with native species.

DWR prepared a Preliminary Engineering Technical Report (2002) for the proposed Iron Canyon Fish Ladder repair. Following this technical report, HDR et al. (2006) evaluated the feasibility of the project. HDR et al. (2006) concluded that no physical constraints would preclude construction of the ladder and that performance of the proposed ladder was expected to surpass that of the existing ladder over its 50-year life span. Improvements to the existing ladder would allow passage to existing spawning and holding habitat over a broader range of flows (HDR et al. 2006).

# Yuba River

## Spawning/ Holding Habitat

Englebright Dam (RM 24) is the upper limit for salmonid migration in the Yuba River (CH2M Hill 1998). The channel below Englebright Dam, referred to as the Lower Yuba River channel, is still strongly influenced by the effects of historical hydraulic mining (ENTRIX and Monroe 2003). The entire Lower Yuba River channel is accessible to both spring and fall-run Chinook for spawning and rearing.

The section just downstream of Englebright Dam to the confluence with Deer Creek does not provide adequate habitat for spring-run spawning due to the bedrock canyon geometry, high velocities, and lack of spawning gravel (Pasternack 2008). This reach is the most heavily impacted, and spring-run were observed clustering in this area where they failed to reproduce (Pasternack 2008).

Below this reach is the Rose Bar reach, as defined by ENTRIX and Monroe(2003), which has a relatively complex stream morphology consisting of deep pools, long riffles and runs, low amounts of fine sediment, and low water temperatures (ENTRIX and Monroe 2003). This reach has good spawning gravel and provides adequate spawning and holding habitat for spring-run Chinook (ENTRIX and Monroe 2003). Pasternack (2008) noted that this section is incising due to a lack of sediment influx but nevertheless is geomorphically self-sustaining, with excellent Chinook salmon spawning habitat and sufficient gravel supplies.

The next reach, Parks Bar, is approximately 6 miles long between the Rose Bar Reach and Daguerre Point Dam. The channel is less sinuous with wide, flat, fluvial terraces and sparse riparian habitat (ENTRIX and Monroe 2003). The upper 2 to 3 miles of the reach are similar to the Rose Bar reach and provide the best spawning and holding habitat in this reach; however, spawning does occur throughout the reach along the cobble bars and the backwater areas of side channels (ENTRIX and Monroe 2003).

Both the Rose Bar and Parks Bar reaches support steelhead spawning, but habitat availability and quality may be more limiting due to the preponderance of larger cobble and small boulders (ENTRIX and Monroe 2003). Pasternack (2008) noted that there are temporary local patches of finer gravel for steelhead spawning.

The Daguerre reach, beginning at the Daguerre Point Dam (RM 11) and ending at the confluence with the Feather River, is used by adult spring-run only as a migration corridor. The river gradient decreases in this stretch and the floodplain widens, with only a few deep pools (ENTRIX and Monroe 2003). Summer water temperatures and the lack of sufficient holding pools make the reach unsuitable for spring-run spawning and holding.

CDFG (1991) calculated that spring flows of 1,000 cfs in April, 2,000 cfs in May, and 1,500 cfs would provide adequate spring-run Chinook attraction and adult migration flows. Flows at 700 cfs would provide adequate conditions for salmonid adult migration and spawning, and would prevent redd dewatering between mid-October and March (CDFG 1991).

## Rearing Habitat

All three reaches provide suitable rearing habitat, and the upper reaches provide adequate year-round temperatures to support the spring-run yearling life stage. However, the Daguerre reach may not be as suitable in some years, especially low-flow years, due to higher water temperatures and more predation pressure (ENTRIX and Monroe 2003). Based on an analysis conducted by CDFG (1991), the greatest amount of rearing habitat for fry occurs at flows of 100 cfs and between 150 and 200 cfs for juvenile Chinook. However, CDFG calculated that flows near 700 cfs between mid-October and March did not significantly reduce the amount of fry and juvenile habitat while benefitting early outmigrant spring-run juveniles and spawning adults. The higher spring flows (1,000 to 2,000 cfs) also reduce the amount of fry and juvenile habitat but are necessary for the needs of other life stages (CDFG 1991).

The greatest amount of steelhead fry habitat occurs between 100 and 200 cfs (CDFG 1991). For steelhead, juvenile flows between 200 and 350 cfs maximize the amount of rearing habitat; however, spawning steelhead need flows between 600 and 800 cfs (CDFG 1991). Below Daguerre Point Dam, adequate juvenile steelhead rearing conditions are available when flows are between 250 and 450 cfs, between July and mid-October (CDFG 1991).

## Limiting Factors

Englebright Dam is an impassable barrier to spring-run migration into the upper reaches of the watershed, limiting spawning habitat availability. The lack of spawning habitat and gravel in the reach just below Englebright Dam also can affect spring-run production in the Yuba River (Pasternack 2008). In the reach below Daguerre Point Dam, gravel recruitment is limited except when flows are high enough to move gravel from the mined debris along the edge of the riverbank (ENTRIX and Monroe 2003). Because of no spatial separation with fall-run, redd superimposition can occur in the two reaches above Daguerre Point Dam (ENTRIX and Monroe 2003).

Spring-run passage through the fish ladder on Daguerre Point Dam can be delayed when springtime flows are less than 400 cfs or greater than 2,500 cfs (ENTRIX and Monroe 2003). Steelhead passage at Daguerre Point Dam can be delayed when fall flows are greater than 2,000 cfs (ENTRIX and Monroe 2003). When passage is delayed for an extended period, the chance of injury associated with attempting to pass over the dam face is increased; or a loss of condition can affect egg production (ENTRIX and Monroe 2003).

The existing riparian habitat below Daguerre Point Dam only minimally benefits rearing salmonids (CDFG 1991). The loss of riparian habitat reduces nutrient inputs to the river and increases water temperatures, making the lowest portion of the river less suitable for juvenile Chinook and steelhead rearing. Entrainment of juvenile Chinook in agricultural diversions also reduces spring-run Chinook and steelhead production in the Yuba River. There are three major diversions facilities on the Lower Yuba River: Browns Valley Irrigation, Hallwood-Cordua, and South Yuba and Brophy Water Districts (CDFG 1991).

## Monitoring Activities

CDFG and USFWS conducted spring-run spawning surveys on the Yuba River between 1999 and 2003; historically, annual surveys were conducted only sporadically starting in 1972 (ENTRIX and Monroe 2003). In 2003, CDFG installed a Vaki River-Watcher system in the fish ladders on Daguerre

Point Dam. The automated fish counters allow for continuous monitoring of adult salmonid passage through the fish ladders and evaluation of the temporal distribution of Chinook salmon and steelhead populations and straying rates of non-native salmonids.

## Restoration Activities

The Yuba County Water Agency (YCWA) worked with a coalition of stakeholders and agencies to develop a set of agreements that form the proposed Lower Yuba River Accord (Yuba Accord) (YCWA 2005). The Yuba Accord resolves nearly 15 years of litigation over instream flows requirements for the Lower Yuba River (YCWA 2005) that were recommended in the CDFG Lower Yuba River Fisheries Management Plan. The Yuba Accord has three separate proposed agreements: a Fisheries Agreement, a Water Purchase Agreement, and a Conjunctive Use Agreement (YCWA 2005).

The Fisheries Agreement establishes new instream flow requirements based on the water-year type (YCWA 2005). The higher flows will improve instream habitat conditions during summer and fall months in part for spring-run holding and spawning, and juvenile steelhead rearing. The agreement also provides funding for long-term scientific fisheries monitoring, studies, and enhancement projects (YCWA 2005). Implementation of the instream flows was started on an interim basis in 2006, with full implementation to begin in 2008. The final environmental impact report/environmental impact statement for the Yuba Accord was completed in October 2007.

The Daguerre Point Dam Fish Passage Improvement Project was initiated, with DWR and the U.S. Army Corps of Engineers (USACE) as lead agencies, to address the fish passage problem identified at Daguerre Point Dam (Wood Rodgers 2003). The goal of the project is to improve upstream and downstream passage for salmonids while keeping water interests whole and not increasing the risk of flood (Wood Rodgers 2003). Wood Rodgers (2003) evaluated the benefits, limitations, and estimated cost of the alternative projects identified by the Yuba River Technical Working Group. The alternatives include: (1) no action; (2) build new fish passage facilities at either the existing location or at a new location or low-head weirs; (3) notch the dam; (4) construct either a short or long reach natural channel around the dam; and (5) remove the dam and construct new fish screens and pump stations at the existing location or 3 miles upstream (Wood Rodgers 2003).

In November 2007, University of California, Davis, USFWS, and USACE implemented an experimental gravel injection project just below Englebright Dam to evaluate its use as a habitat enhancement tool for spring-run Chinook (Pasternack 2008). Because flows were not sufficiently high in winter 2008 to mobilize the gravel, the results from the project are not yet available. However, modeling efforts conducted as part of the project demonstrated constriction of the upper part of the Englebright reach, which limits the potential for gravel deposition (Pasternack 2008). Pasternack (2008) concluded that this reach is not geomorphically self-sustaining like the reach below, scour is focused on the center of the channel preventing cross-channel gravel riffles from forming, and gravel deposition would occur only along channel margins and recirculation zones. In addition, shot rock has replaced a large point bar, composed of spawning gravel, and is taking up potential deposition space (Pasternack 2008).

The Upper Yuba River Studies Program Study Team (Study Team) prepared a watershed habitat assessment of the Upper Yuba River for DWR in 2007. The purpose of the assessment was to determine the biological, environmental, and socioeconomic feasibility of introducing Chinook salmon and steelhead into the watershed above Englebright Dam (UYRSPST 2007). The assessment focused on the Middle and South Yuba River because the North Yuba River is blocked by New

Bullards Bar Dam (UYRSPST 2007). Water temperatures could potentially limit the use of both forks by Chinook and steelhead. Field studies conducted in 2003 suggested that water temperatures were problematic; however, further analysis conducted in 2004 found that temperatures were thermally suitable for holding on a portion of the Middle Yuba River (UYRSPST 2007).

Approximately 5.6 miles of habitat on the Middle Yuba River were thermally suitable, and 0.5 mile was within the optimal range for spring-run Chinook holding and spawning below a natural barrier (UYRSPST 2007). The Study Team (UYRSPST 2007) estimated that combined habitat would support approximately 600 spring-run Chinook. An increase in flow would extend the habitat by an additional 11.7 miles and support a total of 1,650 spring-run Chinook. The increased flow also would provide 14 miles of steelhead spawning habitat supporting approximately 2,640 adults (UYRSPST 2007). Under 2004 operations, conditions were suitable for fall-run Chinook; therefore, hybridization and redd superimposition could reduce spring-run production on the Middle Yuba River (UYRSPST 2007).

2004 operations provided suitable habitat and thermal conditions to support other life stages of both spring-run Chinook and steelhead on the Middle Yuba River. Given the results, the Study Team determined that the upper watershed is capable of supporting salmonids and that increased flow would lengthen the amount of thermally suitable habitat for both spring-run Chinook and steelhead on the Middle Yuba River (UYRSPST 2007). The South Yuba River did not have suitable thermal conditions under 2004 operations, but operational changes could lower water temperatures to support spring-run Chinook and steelhead spawning (UYRSPST 2007).

NMFS recently issued a contract for a watershed-based habitat suitability assessment and conceptual plans for engineered fish passage design alternatives to allow fish passage through or around Englebright Dam (Edmondson pers. comm.). The contract is scheduled for completion by the end of the fiscal year 2009. The plan will, in part, identify potential habitat, facilities, and conceptual-level operation procedures and will clarify the hydropower regulatory environment among the multiple licensees and agencies (Edmonson pers. comm.).

The lower Yuba River does not have a self-sustaining, independent population of spring-run Chinook; however, it does have a small spring-run population that is supported by Feather River Hatchery operations (DWR 2007, Lindley et al. 2007). The lower Yuba River has a relatively naturalized flow regime and substantial sediment storage that will support reach-scale rehabilitation (Pasternack 2008). Therefore, this small population could benefit from restoration activities. However, the Yuba River continues to experience hybridization between spring-run and fall-run Chinook due to the lack of spatial and temporal separation (Yoshiyama et al. 2001). Fish passage around Englebright Dam could be managed to provide access to spawning, holding, and rearing habitat for both spring-run Chinook and steelhead and could provide spatial separation between spring-run and fall-run Chinook.

# American River

## Spawning/ Holding Habitat

By 1955, with the completion of Folsom and Nimbus Dams, spring-run Chinook were extirpated from the American River. No suitable habitat for spring-run exists in the lower American River.

Steelhead are currently limited to the lower 23 miles of the American River at the confluence with the Sacramento River to Nimbus. The upper portion of lower American River from Nimbus Dam to Goethe Park (RM 14) provides a diversity of aquatic habitat unrestricted by levees, while the section downstream from Goethe Park is bordered by levees resulting in a reduction in river meander and a deeper channel (SWRI 2001).

Snider and Beak Consultants, Inc. (1992) developed a geomorphically based habitat classification system for the lower American River that divided the lower river into three reaches. Reach 1, from the confluence to Paradise Beach Recreation Area, is approximately 5 miles long and characterized by a very low channel gradient and tidal fluctuations (SWRI 2001). The reach is dominated with long uniform flatwater stretches along with bar complexes consisting of glide and pool habitats only (SWRI 2001). Reach 2, from Paradise Beach Recreation Area to the Gristmill Dam Recreation Area, is approximately 7 miles long and is characterized by a predominately sand-bed channel dominated with flatwater areas (SWRI 2001). However, Reach 2 also has eight off-channel features and bar complexes with all four habitat types (riffle, run, glide, and pool) (SWRI 2001). Reach 3, from Gristmill Dam Recreation Area to Nimbus Dam, is approximately 11 miles long and is characterized by a relatively high gradient, gravel bed channel. Reach 3 has less flatwater area than the other two reaches, five off-channel features, and various bar complexes with all four habitat types (SWRI 2001).

Most spawning occurs in the upper 3 miles of the lower American River (NMFS 2004). The total spawning area peaks at flows of 2,400 cfs, but the availability varies only slightly between 1,000 and 4,000 cfs (NMFS 2004).

## Rearing Habitat

Conditions from Watt Avenue (RM 9) to Nimbus Dam are generally suitable for the year-round rearing necessary for steelhead. Steelhead occasionally can be found rearing slightly lower in the river between Paradise Beach (RM 5) and Watt Avenue, depending on water temperatures (SWRI 2001).

## Limiting Factors

High water temperature between July and September is probably the primary factor limiting steelhead production in the lower American River (SWRI 2001). NMFS set the temperature objective at a daily mean temperature of 65 °F at Watt Avenue for juvenile rearing but can adjust this objective depending on the size of the coldwater pool in Folsom Reservoir each year (NMFS 2004). In years with a low coldwater pool, water temperatures can exceed 65 °F between May and October; temperatures can reach 75 °F in July and August (NMFS 2004).

Flood control releases in spring can cause redd scouring, and the flow reductions following the releases can cause redd dewatering or stranding of fry and juveniles (NMFS 2004). In addition, harvest impacts (angling), hatchery practices, loss of riparian habitat, and predation may limit steelhead production in the lower American River (SWRI 2001).

## Monitoring Activities

Since 2001, CDFG has conducted redd surveys and live adult counts for steelhead to estimate the number of in-river spawners, spawning distribution and time, and the percent of hatchery to wild

spawners. CDFG staff surveys every 2 weeks from December 20 through the first week in April, from Nimbus Dam (RM 23) to Paradise Beach (RM 5). The surveys are conducted by jet boat, walking, or snorkeling.

## Restoration Activities

Reclamation operates Folsom and Nimbus Dams as part of the CVP; flows are managed on the lower American River to provide flood protection, water supplies, hydropower, recreational opportunities, and water quality control in the Delta (Water Forum 2005). Reclamation also manages flows to protect fish and wildlife downstream of Nimbus Dam. The American River Operations Work Group (AROG) meets once or twice a month to focus on real-time flow and water temperature management on the lower American River and provides operational recommendations to Reclamation (Water Forum 2005).

In the 1980s, the lower American River was designated as a "Recreational River" under both the California Wild and Scenic Rivers Act and the National Wild and Scenic Rivers Act. This designation provides additional protection to the scenic, wildlife, historic, cultural, and recreational value of the river (Water Forum 2005).

In 1994, the Water Forum was formed of a diverse group of business and agricultural leaders, citizen groups, environmental groups, water managers, and local governments in Sacramento County. Its purpose is to guide development of a regional solution in order to provide a reliable and safe water supply and to preserve the fishery, wildlife, recreational, and aesthetic values of the lower American River. A Memorandum of Understanding for the Water Forum Agreement that was signed in 2000 allows the region to meet its needs in a balanced way through year 2030 (Water Forum 2000).

In 2002, the Lower American River River Corridor Management Plan (RCMP) was developed by the Lower American River Task Force, with support from Sacramento Area Flood Control Agency (SAFCA), the Water Forum, and Sacramento County (Water Forum 2005). The RCMP sets goals, objectives, and actions for four distinct elements: fisheries and in-stream habitat management, vegetation and wildlife management, flood management, and recreation management. The Fisheries and Instream Habitat (FISH) Workgroup of the Lower American River Task Force developed a FISH Plan that works as a single blueprint to identify and prioritize opportunities to improve the fish and aquatic habitats in the lower American River; this plan serves as the habitat management element of the RCMP (Water Forum 2005). The goals of the FISH Plan is to increase and maintain viable populations of naturally spawning fall-run Chinook salmon, steelhead, and splittail; restore and maintain an appropriate distribution and abundance of other native species; and sustain American shad and striped bass fisheries consistent with restoring native species.

The three key areas in managing the river to protect fall-run Chinook and steelhead involve improving water temperatures and flow; restoring, maintaining, and improving fish habitat; and reducing the impact of water supply diversions (Water Forum 2005). Recent improvements related to the FISH Plan include improving and updating the flow management standards, minimizing flow fluctuations, constructing and operating a temperature control device on Folsom Dam to improve cool water pool management, implementing the Discovery Park floodplain habitat enhancement project, reducing surface water diversions, removing non-native invasive plants, and increasing riparian habitat (Water Forum 2005).

Reclamation, through CVPIA projects, has placed approximately 6,000 tons of gravel in the three sites on the lower American River to improve spawning habitat (Reclamation and USFWS 2009). In addition, several AFRP projects totaling $501,000 have been completed including an instream flow study and a temperature reduction modeling project.

Construction of Folsom and Nimbus Dams completely blocked access to spawning habitat for both spring-run Chinook and steelhead in the American River. While no suitable habitat exists in the lower American River for spring-run, a small population of steelhead remains. Water temperatures in summer and fall, flow fluctuations, and limited spawning habitat limit the potential recovery for steelhead in the American River basin.

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Appendix E

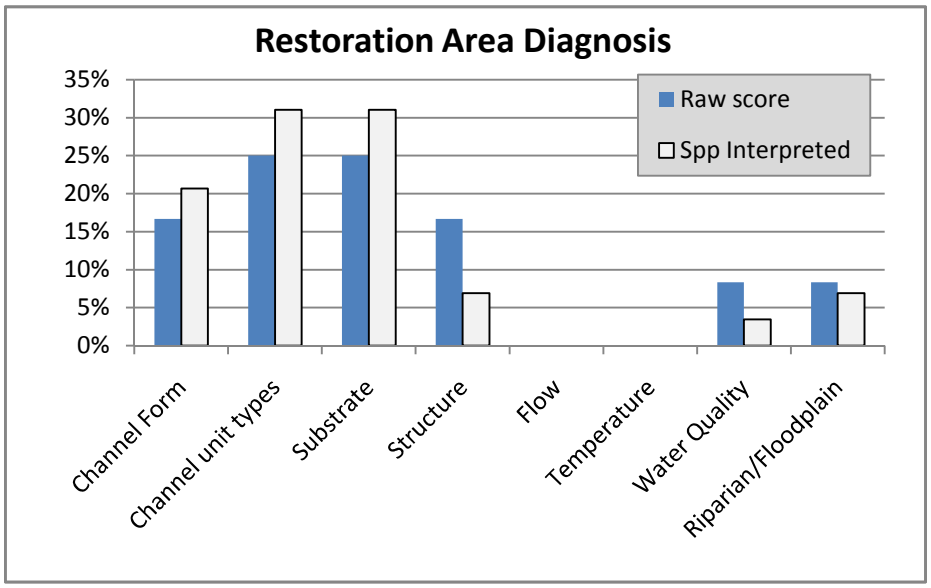
# Action-Specific Calculations of Contribution to the Habitat Expansion Threshold

Lower Yuba River Habitat Expansion Actions

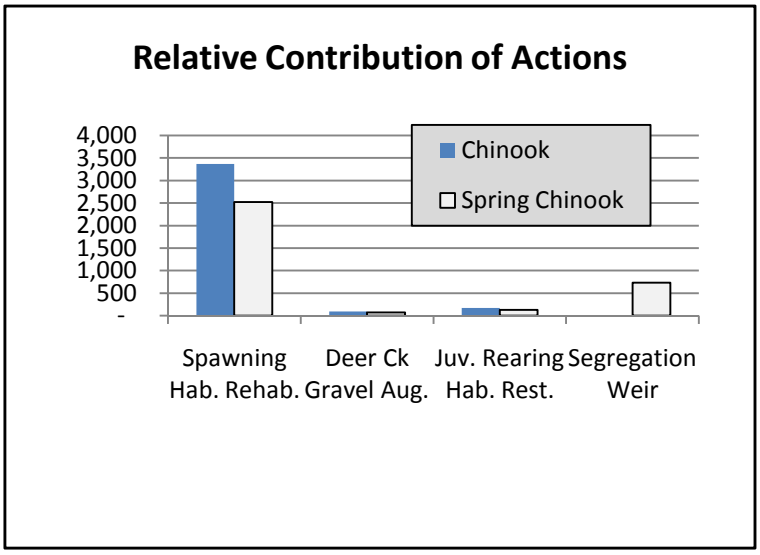
Englebright Dam to below Daguerre Point Dam

This project addresses habitat constraints in the Yuba River below Englebright Dam. The main action is to rehabilitate spawning habitat in the Englebright Dam reach of the Yuba River (i.e., Englebright Dam to Deer Creek) by removing shot rock and adding gravel. Gravel would also be supplied to lower Deer Creek to provide local spawning benefits and to supply downstream gravel. Floodplain/side channel improvements would be made in the Yuba Goldfields area downstream to restore rearing habitat for juveniles. An segregation weir to block fall-run Chinook is optional.

| | Chinook |
|---|---|
| Current Abundance | 250 |
| Reference Abundance | 5,000 |
| Recovery Potential | 4,750 |
| | |
| Passage Mortality | 5% |
| Proportion Spring Chinook | 75% |




| Actions | Chinook Salmon | Spring Chinook |
|---|---|---|
| Spawning Habitat Rehabilitation | 3,365 | 2,523 |
| Deer Creek Gravel Augmentation | 94 | 70 |
| Juvenile Rearing Habitat Restoration | 173 | 130 |
| Segregation Weir | - | 735 |
| Total | 3,631 | 3,459 |



## Lower Yuba River Habitat Expansion Actions
## Englebright Dam to below Daguerre Point Dam
### Summary of calculations, assumptions, and sources used in calculating the HET Contribution

| | Calculations/Assumption(s) | Source |
|---|---|---|
| **Current Abundance** | Estimated based on recent video monitoring results. | NMFS BO (2007) |
| **Reference Abundance** | Determined based on estimates provided in HEA Questionnaire. | D. Massa (pers comm 2009) |
| **Passage Mortality** | Estimated to be low and associated with Daguerre Point Dam. | Tech Comm. BPJ |
| **Proportion Spring Chinook** | Based on observations of fall-run spawning distribution and assumed distribution of spring-run in upper reaches. | Tech Comm. BPJ and Massa (2008) |

**Habitat Rating Scores**[1]

| | | |
|---|---|---|
| **Channel Form** | Altered by the effects of Englebright Dam; much room for improvement. | Tech Comm. BPJ |
| **Channel unit types** | See Channel Form. | Tech Comm. BPJ |
| **Substrate** | See Channel Form. | Tech Comm. BPJ |
| **Structure** | See Channel Form. | Tech Comm. BPJ |
| **Flow** | Lower Yuba River Accord fish flows in place; no room for improvement. | Tech Comm. BPJ |
| **Temperature** | Cold-water releases from New Bullards Bar meet temperature criteria; no room for improvement. | Tech Comm. BPJ |
| **Water Quality** | Not identified as an issue in the lower Yuba River; some room for improvement. | Tech Comm. BPJ |
| **Riparian/ floodplain** | Altered by the effects of Englebright Dam and mining activities; some room for improvement. | Tech Comm. BPJ |

**Potential of Action Types**

| | | |
|---|---|---|
| **Spawning Rehabilitation** | Potential to improve 100% of substrate, 95% of channel form, 95% of channel unit types, and 5% of temperature issues. | Tech Comm. BPJ |
| **Gravel Augmentation** | Potential to slightly improve channel form and structure, but greatly improve channel unit types and substrate. | Tech Comm. BPJ |

**Action Intensity**

| | | |
|---|---|---|
| **Spawning Rehabilitation** | Estimated to improve spawning habitat by 93% since it does not address the entire spawning reach. | Tech Comm. BPJ |
| **Gravel Augmentation** | Estimated to improve spawning habitat by 5% since it is a small scale project in Deer Creek. | Tech Comm. BPJ |
| **Floodplain Improvements** | Estimated to improve juvenile rearing by 10% since it is a small scale project in the Yuba Goldfields. | Tech Comm. BPJ |
| **Segregation Weir** | Estimated to improve the spatial segregation by 90% since weirs are not 100% effective under all conditions. | Tech Comm. BPJ |

Tech Comm. BPJ = HEA Technical Committee Best Professional Judgement

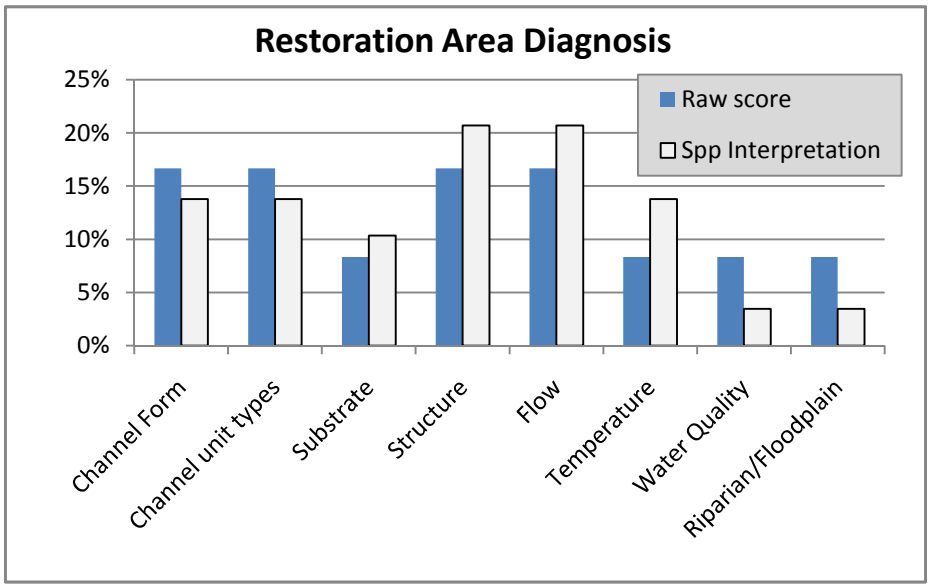
[1]Habitat rating scores based on Englebright Dam reach only.

Antelope Creek Habitat Expansion Action

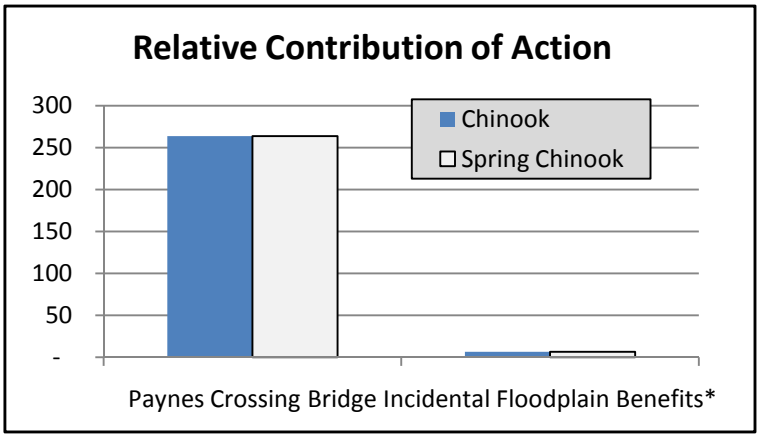
Paynes Crossing

This project involves replacing the existing instream roadway at Paynes Crossing with a clear span bridge. The project would allow natural stream function in passage of fish and bedload, and would improve localized narrowing of the channel. This would allow increased upstream and downstream migration in the summer holding and spawning reach for spring-run Chinook salmon.

| | Chinook |
|---|---|
| Current Abundance | 40 |
| Reference Abundance | 500 |
| Recovery Potential | 460 |
| | |
| Passage Mortality | 75% |
| Proportion Spring Chinook | 100% |




| Action | Chinook Salmon | Spring Chinook |
|---|---|---|
| Paynes Crossing Bridge Construction | 264 | 264 |
| Incidental Floodplain Benefits* | 7 | 7 |
| Total | 271 | 271 |




*Impacts of action on riparian/floodplain condition

## Antelope Creek Habitat Expansion Action
## Paynes Crossing
### Summary of calculations, assumptions, and sources used in calculating the HET Contribution

| | Calculations/Assumption(s) | Source |
|---|---|---|
| **Current Abundance** | Averaged estimates from 1999-2008 | DFG GrandTab 2009 |
| **Reference Abundance** | Estimated as the likely upper threshold due to naturally occuring flow limitations; historical DFG estimates. | C. Harvey-Arrison (pers comm 2009); CH2M Hill (1998) |
| **Passage Mortality** | Estimated to be high based on the numerous passage issues (braided channel, ag diversions, and Paynes Crossing) in low-flow years. | Tech Comm. BPJ |
| **Proportion Spring Chinook** | Natural segregation occurs in Antelope Creek. | Tech Comm. BPJ |

**Habitat Rating Scores**

| | | |
|---|---|---|
| **Channel Form** | Altered by the instream crossing; also likely that braided channel in valley reach reflects change in channel form; much room for improvement. | Tech Comm. BPJ |
| **Channel unit types** | The upper watershed is relatively undisturbed from the historical condition; some room for improvement. | Tech Comm. BPJ |
| **Substrate** | See Channel Unit types | Tech Comm. BPJ |
| **Structure** | Assumed to have been altered in valley reach; much room for improvement. | Tech Comm. BPJ |
| **Flow** | The upper watershed is relatively undisturbed from the historical condition; ag diversions alter flow in valley reach; much room for improvement. | Tech Comm. BPJ |
| **Temperature** | Increased flow could improve temperature; some room for improvement. | Tech Comm. BPJ |
| **Water Quality** | Generally good but some room for improvement related to ag return water in valley reach. | Tech Comm. BPJ |
| **Riparian/ floodplain** | Historical condition in valley reach unknown; some room for improvement. | Tech Comm. BPJ |

**Potential of Action Types**

| | | |
|---|---|---|
| **Passage improvements** | Potential to improve passage by 90% given that all streams have some naturally occuring passage impediments. | Tech Comm. BPJ |

**Action Intensity**

| | | |
|---|---|---|
| **Passage improvements** | Estimated to improve passage by 85% since it does not address passage impediments in the valley floor reach. | Tech Comm. BPJ |
| **Floodplain improvements** | Passage improvements provides some incidental benefits. | Tech Comm. BPJ |

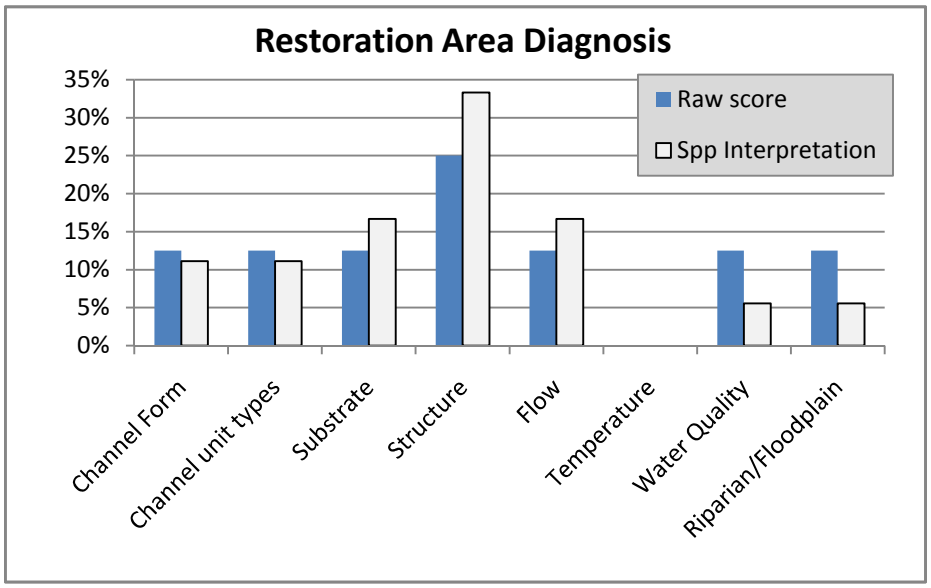
Tech Comm. BPJ = HEA Technical Committee Best Professional Judgement

Big Chico Creek Habitat Expansion Action

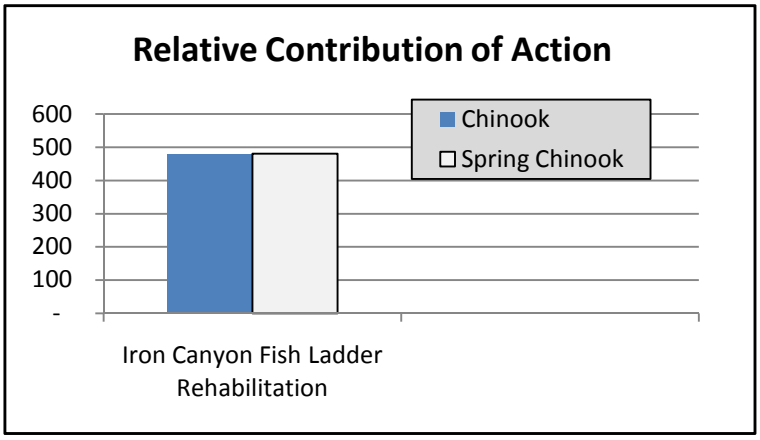
Iron Canyon

This project would repair, expand, or modify existing weirs and install six new weirs at the Iron Canyon Fish Ladder. Rehabilitating the ladder would allow it to function effectively over a broader range of flows, facilitating the upstream passage of spring-run Chinook salmon and steelhead, thus increasing their escapement and providing access to juvenile rearing habitat.

| | Chinook |
|---|---|
| Current Abundance | 50 |
| Reference Abundance | 1,000 |
| Recovery Potential | 950 |
| | |
| Passage Mortality | 75% |
| Proportion Spring Chinook | 100% |




| Action | Chinook Salmon | Spring Chinook |
|---|---|---|
| Iron Canyon Fish Ladder Rehabilitation | 481 | 481 |
| Total | 481 | 481 |



## Big Chico Creek Habitat Expansion Action
## Iron Canyon
### Summary of calculations, assumptions, and sources used in calculating the HET Contribution

| | Calculations/Assumption(s) | Source |
|---|---|---|
| **Current Abundance** | Averaged estimates from 1999-2008 | DFG GrandTab 2009 |
| **Reference Abundance** | Determined based on the likely upper threshold; historical DFG estimates. | T. McReynolds (pers comm 2009); CH2M Hill (1998) |
| **Passage Mortality** | Estimated to be high based on the numerous passage issues ( flood control weirs, Iron Canyon Fish ladder, ag diversions) in low-flow years. | Tech Comm. BPJ |
| **Proportion Spring Chinook** | Natural segregation occurs in Big Chico Creek. | Tech Comm. BPJ |

**Habitat Rating Scores**

| | | |
|---|---|---|
| **Channel Form** | Upper watershed relatively undisturbed from historical condition; flood control structures and concrete swimming pool downstream assumed to be part of reference condition; some room for improvement. | Tech Comm. BPJ |
| **Channel unit types** | The upper watershed is relatively undisturbed from the historical condition; some room for improvement. | Tech Comm. BPJ |
| **Substrate** | See Channel Unit types. | Tech Comm. BPJ |
| **Structure** | See Channel Unit types. | Tech Comm. BPJ |
| **Flow** | The upper watershed is relatively undisturbed from the historical condition; ag diversions alter flow in the valley reach; some room for improvement in the valley reach. | Tech Comm. BPJ |
| **Temperature** | Temperature for spring-run suitable above Iron Canyon but too warm below; natural conditions, so no room for improvement. | Tech Comm. BPJ |
| **Water Quality** | Generally good but some room for improvement related to ag return water in valley reach. | Tech Comm. BPJ |
| **Riparian/ floodplain** | The upper watershed is relatively undisturbed from the historical condition; valley reach impacted by ag levees and flood control structures; some room for improvement. | Tech Comm. BPJ |

**Potential of Action Types**

| | | |
|---|---|---|
| **Passage improvements** | Potential to improve passage by 90% given that all streams have some naturally occuring passage impediments. | Tech Comm. BPJ |

**Action Intensity**

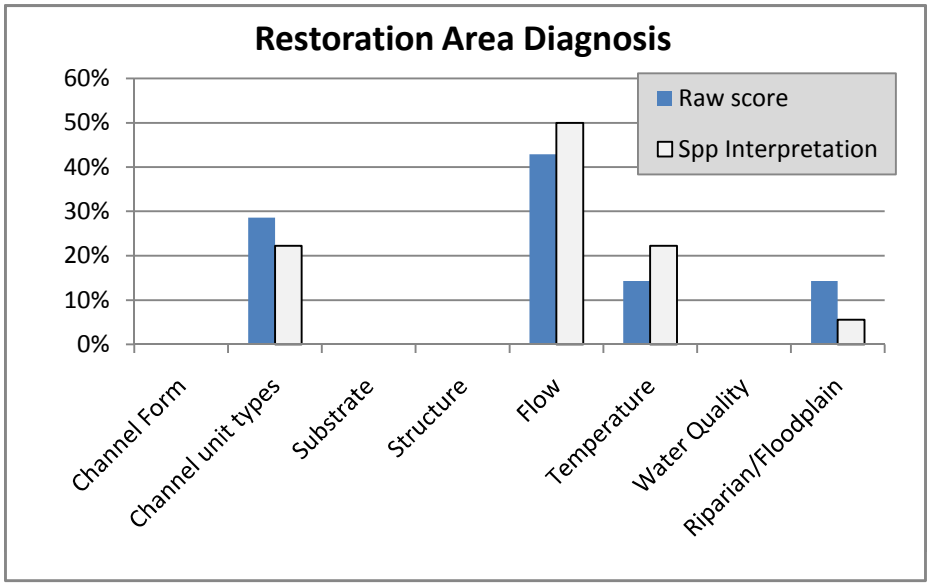
| | | |
|---|---|---|
| **Passage improvements** | Estimated to improve passage by 75% since it does not address passage impediments in the valley floor reach. | Tech Comm. BPJ |

Tech Comm. BPJ = HEA Technical Committee Best Professional Judgement

Battle Creek Habitat Expansion Actions
South Fork Battle Creek and Tributaries

This project would help restore habitat for spring-run Chinook salmon and steelhead in South Fork Battle Creek and its tributaries. It includes the removal of four diversion dams, installation of a fish screen and ladder at another dam, and installation of a tailrace connector between a powerhouse and canal to prevent mixing of water between the North and South Forks. The project would restore access to 16.3 miles of prime historic spring-run Chinook salmon and steelhead habitat, increase flows, reduce temperatures, and prevent entrainment of emigrating juveniles.

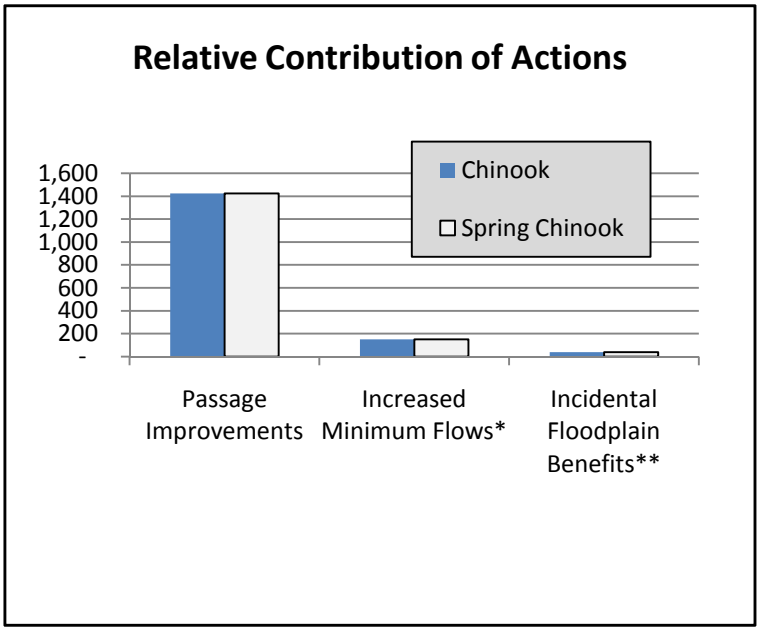
| | Chinook |
|---|---|
| Current Abundance | 40 |
| Reference Abundance | 2,000 |
| Recovery Potential | 1,960 |
| | |
| Passage Mortality | 85% |
| Proportion Spring Chinook | 100% |




| Actions | Chinook Salmon | Spring Chinook |
|---|---|---|
| Passage Improvements at Dams (Removals, Screens, Ladders, Tailrace Connectors) | 1,424 | 1,424 |
| Increased Minimum Flows* | 150 | 150 |
| Incidental Floodplain Benefits** | 39 | 39 |
| Total | 1,614 | 1,614 |

*Flow increases due to dam removals

**Impacts of actions on riparian/floodplain condition



**Battle Creek Habitat Expansion Actions**
**South Fork Battle Creek and Tributaries**
**Summary of calculations, assumptions, and sources used in calculating the HET Contribution**

| | Calculations/Assumption(s) | Source |
|---|---|---|
| **Current Abundance** | Averaged estimates from 1999-2008; North Fork, South Fork, and the mainstem have approximately equal usable habitat areas, so number divided by 3 to get estimate for South Fork. | DFG GrandTab 2009; Technical Team BPJ |
| **Reference Abundance** | Estimate provided on HEA Questionnaire; historical estimates. | M. Berry (pers comm 2009); Kier Associates (1999) |
| **Passage Mortality** | Estimated to be high based on the number of small dams and the barrier weir at Coleman Hatchery. | Tech Comm. BPJ |
| **Proportion Spring Chinook** | Natural segregation in Battle Creek and fall-run excluded by Coleman Hatchery Weir. | Tech Comm. BPJ |

**Habitat Rating Scores**

| | | |
|---|---|---|
| **Channel Form** | Relatively unchanged from historical condition; no room for improvement. | Tech Comm. and Steitz and Geary (pers comm) BPJ |
| **Channel unit types** | Altered by flow regime for power generation; room for improvement. | Tech Comm. and Steitz and Geary (pers comm) BPJ |
| **Substrate** | Small diversion dams not retaining gravel or woody debris; no room for improvement. | Tech Comm. and Steitz and Geary (pers comm) BPJ |
| **Structure** | See Substrate. | Tech Comm. and Steitz and Geary (pers comm) BPJ |
| **Flow** | Substantially altered for power generation; most room for improvement. | Tech Comm. and Steitz and Geary (pers comm) BPJ |
| **Temperature** | Altered by decreased flows; some room for improvement. | Tech Comm. and Steitz and Geary (pers comm) BPJ |
| **Water Quality** | See Channel Form. | Tech Comm. and Steitz and Geary (pers comm) BPJ |
| **Riparian/ floodplain** | Altered by change in flow regime downstream of the project area; some room for improvement. | Tech Comm. and Steitz and Geary (pers comm) BPJ |

**Potential of Action Types**

| | | |
|---|---|---|
| **Passage improvements** | Potential to improve passage by 90% given that all streams have some naturally occuring passage impediments. | Tech Comm. BPJ |
| **Flow augmentation** | Potential to improve all eight habitat attributes, but mostly flow, substrate, and temperature. | Tech Comm. BPJ |

**Action Intensity**

| | | |
|---|---|---|
| **Passage improvements** | Estimated to improve passage by 95% since it removes all but one dam (will be retrofitted with a fish ladder). | Tech Comm. and Steitz and Geary (pers comm) BPJ |
| **Flow augmentation** | New minimum flow requirements will return ~80% of the historical flow. | Tech Comm. and Steitz and Geary (pers comm) BPJ |

Tech Comm. BPJ = HEA Technical Committee Best Professional Judgement

# Sources

## Printed References

California Department of Fish and Game (DFG). 2009. GrandTab. California Central Valley Sacramento and San Joaquin River systems Chinook salmon escapement hatcheries and natural areas. Last revised: 2/18/2009. Available:< nrm.dfg.ca.gov/FileHandler.ashx?DocumentVersionID=26269>. Accessed: September 10, 2009.

CH2M Hill. 1998. Central Valley Project Improvement Act Tributary Production Enhancement Report. Draft report to Congress. Prepared for U.S. Fish and Wildlife Service. Sacramento, CA.

Kier Associates. 1999. Battle Creek Salmon and Steelhead Restoration Plan. Prepared for the Greater Battle Creek Watershed Working Group. January. Sausalito, CA.

Massa, D. 2008. Lower Yuba River Chinook salmon escapement survey, California Department of Fish and Game, Chico, CA.

Massa, Duane. 2009. California Department of Fish and Game, Chico, CA. Lower Yuba River Narrows Gravel Rehabilitation Project. Habitat Expansion Questionnaire provided to HEA Steering Committee.

National Marine Fisheries Service. 2007. Biological opinion for the U.S. Army Corps of Engineers' operation of Englebright and Daguerre Point Dams on the Yuba River, California. Southwest Region. November 21. Long Beach, CA.

## Personal Communications

Berry, Mike. Fishery Biologist. California Department of Fish and Game, Redding, CA. Phone conversation with Colleen Lingappaiah, ICF Jones & Stokes, regarding the number of spring-run Chinook salmon and steelhead that could be supported by Phase 2 of the Battle Creek Salmon and Steelhead Restoration Project. July 20, 2009.

Harvey-Arrison, Colleen. Associate Fisheries Biologist. California Department of Fish and Game, Northern Region. Telephone conversation with Erin Chappell, California Department of Water Resources. September 28, 2009.

McReynolds, Tracy. Staff Environmental Scientist. California Department of Fish and Game, Northern Region. Telephone conversation with Erin Chappell, California Department of Water Resources. September 28, 2009.

Steitz, Curtis, and Gene Geary. Senior Aquatic Biologists. Pacific Gas and Electric Company. Meeting with Habitat Expansion Agreement Technical Committee during Habitat Expansion Threshold quantification for Battle Creek. September 29, 2009.

Appendix F

# Questionnaires for Recommended Actions

# Habitat Expansion Agreement

for

# Central Valley Spring-Run Chinook Salmon and California Central Valley Steelhead

## Questionnaire Instructions

The attached questionnaire is intended to solicit information needed by the Steering Committee to review projects relative to the criteria established in the Habitat Expansion Agreement. For each proposed action (project), please complete the questionnaire to the fullest extent possible. Please provide citations where applicable and provide a full reference for each citation at the end of this questionnaire (Section X. Supporting Documents). Specific instructions follow.

### I. Contact Information

Provide the name of the agency or group making the proposal as well as a contact person for the project. Include contact information such as mailing address, phone number, and email address.

### II. Project Description

Provide a descriptive name for the action (project). If the action is listed in the *Working List of Potential Habitat Expansion Actions* (provided during the January 2009 meetings of HEA parties), please include the reference number associated with the action. The project location should specify the watershed or subwatershed (e.g., Deer Creek, Beegum Creek) as well as specific areas within the watershed where the project will be located and what portions of the watershed will benefit from the project. Please include geographic coordinates of the project location(s), if applicable. The project description should be a narrative that provides as much detail as possible about the project.

### III. Species Limiting Factors

In this section, indicate the factors that currently limit production of spring-run Chinook salmon and/or steelhead in your watershed. The intent is that the environmental and biological objectives of your project address these limiting factors in some way. Please check one or more of the limiting factors that apply to your watershed. In the second column, describe how and where the factor limits spring-run Chinook salmon and/or steelhead. For each factor that you check, please rank its effect on spring-run Chinook salmon and/or steelhead using the drop-down box in the last column. Finally, we also ask that you describe the source of your conclusions, such as a watershed assessment or other document. Please provide enough information that we can find the document if we need it.

### IV. Project Objectives—Environmental

Environmental objectives describe how the project is intended to address the limiting factors to achieve the biological objective described in the next section. Environmental objectives should be as specific and quantitative as possible (e.g., reduce gravel embeddedness in the watershed from 75% to 25% by fencing riparian areas to exclude cattle and allow riparian forest to reestablish). Describe how you think environmental objectives relate specifically to the biological objectives. In the last column, we ask you to describe the environmental objectives as either the primary or secondary focus of the project. For example, a project to plant trees might have a primary focus on riparian/floodplain function with a secondary focus on temperature or water quality.

## V. Project Objectives—Biological

Biological objectives describe the anticipated biological response from the project and should be as quantitative as possible. Indicate which species and life stages are the focus of the project. Describe specifically the general condition of the target species in your watershed relative to the historical abundance. The condition of the species should be indicated using the categories in the drop-down box. Species condition categories are defined on the last page of this form. Biological objectives should include the following information: (1) an estimate of the expected contribution of the project in terms of potential adult returns, to the extent possible (and an explanation of how the estimate was developed); and (2) an explanation of how the biological objective for the species is addressed by the action relative to the environmental limiting factors (e.g., the biological objective of an action might be to increase egg incubation survival in a watershed that is currently limited by sediment levels).

## VI. Project Cost

To the extent possible, estimate the capital cost of the project, the annual operating and maintenance (O&M) cost, a description of annual O&M activities, and the project lifetime (i.e., how many years O&M activities are expected, including indefinitely, and how long until you expect the project to provide benefits). Provide any confirmed or potential funding partners, or opportunities for cost sharing with other funders or between projects. Also, identify any confirmed or potential partners that might provide maintenance support for the project (funding support or labor support).

## VII. Schedule

Describe the project schedule, including a potential start date, construction period, and environmental and biological response times (i.e., the expected time to realize environmental and biological benefits). The last points refer to the maturation period for the project during which time environmental conditions develop. For example, it may take 50–100 years before full environmental benefits (e.g., shading, channel stability, water quality) of planting riparian trees are realized.

## VIII. Feasibility

Describe the feasibility and challenges of the project. Feasibility issues should include primarily technical issues, success of projects utilizing similar technology, and particular challenges posed by the specific project. Other issues of feasibility that may be included are challenges associated with property ownership, permitting, zoning, and other social-economic-legal issues.

## IX. Project Support

Describe the support or potential conflicts associated with the project. Specifically, provide supporting and cooperating entities (e.g., agencies, non-governmental organizations). Are there cooperating agencies or groups, aside from the potential funding partners mentioned previously? Describe the degree of local support and any known opposition or conflicts with other parties.

## X. Supporting Documents

Provide full references for each citation used to support the information presented in this questionnaire for your project. At a minimum, a reference should include the author(s) name; name of agency/organization (if applicable); title of the document; volume and title of journal, if the document is taken from a professional journal; and publisher, date, and location of publication.

Appendix F1

# Questionnaires received on the Lower Yuba River Actions

# Questionnaire

for

# Information on Potential Projects to Support Spring-Run Chinook Salmon and Steelhead in the Sacramento River Basin for the Habitat Expansion Agreement

**DUE: Friday, February 27, 2009**

**Send completed questionnaires to hea@water.ca.gov**

## I. Contact Information

| | |
|---|---|
| **Name:** | Gary Reedy |
| **Organization:** | South Yuba River Citizens League (SYRCL) |
| **Address:** | 216 Main Street |
| **City, State, Zip Code:** | Nevada City, CA 95959 |
| **Phone Number:** | (530) 265-5961 ext 208 |
| **Email Address:** | gary@syrcl.org |

## II. Project Description

| | |
|---|---|
| **Project Name:** | Backwater, Side-channel, and Riparian/Floodplain Habitat Restoration in the lower Yuba River |
| **Reference No. or New:** | New |
| **Project Location:** | Yuba River downstream of Englebright Dam |

**Project Description:**

At present, a pre-project assessment is being conducted to inform opportunities for juvenile salmonid habitat enhancements (including a pilot riparian revegetation project) at Hammon Bar on the lower Yuba River. The pre-project assessment is addressing the geomorphic, hydrologic, and biotic factors influencing riparian recruitment, growth, and survival in the project area. Current work includes a public outreach component to inform nearby landowners, concerned stakeholders, and watershed groups about the proposed pilot project.

## II. Project Description

We want to expand the current work to evaluate conditions along approximately 3 additional river miles of Western Aggregates land recently placed under conservation easement in agreement with SYRCL downstream of Hammon Bar. Using what we learn from the pre-project assessment and pilot project, we intend to implement large-scale restoration in the Yuba River by creating and restoring backwater, side-channel, and riparian/floodplain habitat in the lower Yuba River.

## III. Species Limiting Factors

**In this section, describe the limiting factors for spring-run Chinook salmon and steelhead in your watershed. The last page of this questionnaire defines the limiting factors.**

| Limiting Factors | Description (from back page) | Rank |
|---|---|---|
| ☒ **Channel Form** | The Yuba River in California's Central Valley was severely degraded by hydraulic and dredger mining, primarily from the mid-19th through mid-20th century. In the Yuba Goldfields reach of the Lower Yuba River, dredger tailings confine the river channel along much of its length, and shaded riverine aquatic habitat, riparian habitat, and floodplain inundation are limited. The resulting reduction in aquatic habitat complexity and diversity has been identified as a limiting factor to salmonid populations, and adversely affects rearing salmonids in particular. | High |
| ☐ **Channel Unit Types** | | Select Rank |
| ☐ **Substrate** | | Select Rank |
| ☒ **Structure** | The Yuba River in California's Central Valley was severely degraded by hydraulic and dredger mining, primarily from the mid-19th through mid-20th century. In the Yuba Goldfields reach of the Lower Yuba River, dredger tailings confine the river channel along much of its length, and shaded riverine aquatic habitat, riparian habitat, and floodplain inundation are limited. The resulting reduction in aquatic habitat complexity and diversity has been identified as a limiting factor to salmonid populations, and adversely affects rearing salmonids in particular. | High |
| ☐ **Flow** | | Select Rank |
| ☐ **Temperature** | | Select Rank |
| ☐ **Water Quality** | | Select Rank |
| ☐ **Passage** | | Select Rank |
| ☒ **Riparian/Floodplain** | The Yuba River in California's Central Valley was severely degraded by hydraulic and dredger mining, primarily from the mid-19th through mid-20th century. In the Yuba Goldfields reach of the Lower Yuba River, dredger tailings confine the river channel along much of its length, and shaded riverine aquatic habitat, riparian habitat, and floodplain inundation are limited. The resulting reduction in aquatic habitat complexity and diversity has | High |

## III. Species Limiting Factors

been identified as a limiting factor to salmonid populations, and adversely affects rearing salmonids in particular.

**Source Documents:**

CVPIA 10-year Implementation Plan

**Additional Notes:**

## IV. Project Objectives—Environmental

**In this section, describe how your project will affect one or more of the limiting factors for spring-run Chinook salmon or steelhead described above.**

| Limiting Factor | Description and Objective | Focus |
|---|---|---|
| ☒ **Channel Form** | Create/restore 5 acres of new backwater or side-channel habitat for rearing juvenile salmonids. | Primary |
| ☐ **Channel Unit Types** | | Select Focus |
| ☐ **Substrate** | | Select Focus |
| ☒ **Structure** | Create/restore 5 acres of new backwater or side-channel habitat for rearing juvenile salmonids, as above. Installation of instream woody material may be used to provide structure. | Primary |
| ☐ **Flow** | | Select Focus |
| ☐ **Temperature** | | Select Focus |
| ☐ **Water Quality** | | Select Focus |
| ☐ **Passage** | | Select Focus |
| ☒ **Riparian/Floodplain** | Create/restore 50 acres of new riparian/floodplain habitat for rearing juvenile salmonids. | Primary |

## V. Project Objectives—Biological

**In this section, describe the objective(s) of your project relative to the goal of providing habitat for spring-run Chinook salmon and steelhead. Indicate the species and life stage that are targeted by the project. (It is okay to have more than one species/life stage target).**

**Target Species:** ☒ Spring-Run Chinook Salmon

**Population Status Specific to Watershed:** Decreasing

**Target Life Stages:**

☐ Spawning ☐ Egg Incubation ☒ Summer Rearing ☒ Winter Rearing

☐ Juvenile Emigration ☐ Adult Immigration ☐ Adult Holding

**Description of Project Objectives:**

Increase habitat complexity (e.g., create/restore backwater and side-channel habitat, physical structure, shaded rivierine aquatic, riparian, and floodplain habitat) to provide for increased growth, protection from predators, and overall increased survival of juvenile salmonids.

**Target Species:** ☒ Steelhead

**Population Status Specific to Watershed:** Decreasing

**Target Life Stages:**

☐ Spawning ☐ Egg Incubation ☒ Summer Rearing ☒ Winter Rearing

☐ Juvenile Emigration ☐ Adult Immigration

**Description of Project Objectives:**

Increase habitat complexity (e.g., create/restore backwater and side-channel habitat, physical structure, shaded rivierine aquatic, riparian, and floodplain habitat) to provide for increased growth, protection from predators, and overall increased survival of juvenile salmonids.

## VI. Project Cost

| | |
|---|---|
| **Capital Cost:** | $2M |
| **Annual Operation and Maintenance Cost:** | $20K |
| **Annual Operation and Maintenance Description:** | Ongoing gravel/riparian augmentation and instream woody material installation |
| **Project Lifespan:** | 30 years |
| **Project Partners (Funding):** | Corps of Engineers, Western Aggregates, PG&E, USFWS Anadromous Fish Restoration Program |
| **Project Partners (Maintenance):** | Corps of Engineers, South Yuba River Citizens League |

## VII. Schedule

| | |
|---|---|
| **Proposed Start:** | 2009 |
| **Expected Time to Completion:** | 2019 |
| **Expected Time to Realize Environmental Benefits:** | 2011; full environmental benefits realized in 2019 |
| **Expected Time to Realize Biological Benefits:** | 2011; full environmental benefits realized in 2019 |

## VIII. Feasibility

| | |
|---|---|
| **Technical Feasibility:** | Pre-project assessment is underway; pilot project soon to be underway; design plans are needed and permits will need to be obtained. |
| **Technical Challenges:** | The Yuba River can be a very active river channel |
| **Related Projects:** | Other easements and publically-owned land are likely to become available for habitat restoration projects on the Yuba River. |
| **Ownership or Permitting Challenges:** | None |
| **Conflicts with Cultural, Zoning, or Other Issues:** | None |

## IX. Project Support

| | |
|---|---|
| **Supporting Entities:** | SYRCL, FWS |
| **Cooperating Entities:** | DFG and NMFS |
| **Degree of Local Support:** | SYRCL has been conducting outreach activities to inform the public about this project |
| **Known Opposition:** | Corps of Engineers commitment to project is unknown. |

## X. Supporting Documents

**Please provide a full reference for each citation used to support the information presented in this questionnaire.**

## X. Supporting Documents

## Definitions of Limiting Factors for Spring-Run Chinook Salmon and Steelhead

### Channel Form

This attribute describes changes to the channel, including incision, aggradation, diking, armoring, and other modifications of the channel adversely affecting spring-run Chinook salmon and steelhead.

### Channel Unit Types

Examples of geomorphic features of the channel that form habitat types for spring-run Chinook salmon and steelhead are pools, riffles, glides, and runs. This attribute describes changes in the frequency and size of such features. For example, removal of large wood may reduce the frequency of pools, presence of steps, or retention of gravel for riffles.

### Substrate

This attribute describes changes in the composition of the substrate of the stream, including increase in fine sediment and lack of gravel recruitment.

### Structure

This attribute describes the loss of structural elements in the stream such as large wood, boulders, undercut banks, and so on. Loss of structure results in a simplification of the channel and influences Channel Form and Channel Unit Types.

### Flow

This attribute addresses modification of the flow regime, including decrease in summer low flow, increased "flashiness," and dewatering of the channel as a result of withdrawals.

### Temperature

Change in water temperature can be attributable to human actions such as removal of riparian shading. This attribute describes the increase in summer water temperature and the loss of temperature refugia (springs or groundwater) as a result of human actions.

### Water Quality

This attribute pertains to the input to the stream of toxins or pollutants that produce adverse impacts on spring-run Chinook salmon or steelhead. This can include chemical pollutants such as fertilizer and pesticides and nutrient sources such as cattle and feedlots.

### Passage

This relates to the effect of impediments to adult or juvenile migration of spring-run Chinook salmon or steelhead, including dams, culverts, channel dewatering, and other structural and channel modifications. Please describe the location of the passage impediment and describe the extent of impediment (i.e., a complete or partial blockage to migration).

### Riparian/Floodplain

This attribute describes the loss of functionality of the riparian forest/vegetation and the connection of the stream to the floodplain during high water and flooding.

## Population Condition Definitions for Section V. Project Objectives—Biological

### Increasing

Adult returns of the target species to the watershed have generally been increasing over the last several years; expectations are that the species is displaying characteristics of a rebuilding or healthy population.

### Stable

Adult returns of the target species to the watershed show no clear trend over the last several years.

### Decreasing

Adult returns of the target species to the watershed are declining over the last several years; the decline in abundance is a cause of concern and characteristic of a potentially unhealthy population.

### Intermittent

Adult returns of the target species are occasionally seen in the watershed, but there is no viable or sustained population in the basin.

### Extirpated

The population has been eliminated from the watershed although the species was present in the past.

### Never Present

The species has never been known to occur in the watershed.

# Questionnaire

for

# Information on Potential Projects to Support Spring-Run Chinook Salmon and Steelhead in the Sacramento River Basin for the Habitat Expansion Agreement

**DUE: Friday, February 27, 2009**

**Send completed questionnaires to hea@water.ca.gov**

## I. Contact Information

| | |
|---|---|
| **Name:** | Gary Reedy |
| **Organization:** | South Yuba River Citizens League (SYRCL) |
| **Address:** | 216 Main Street |
| **City, State, Zip Code:** | Nevada City, CA 95959 |
| **Phone Number:** | (530) 265-5961 ext 208 |
| **Email Address:** | gary@syrcl.org |

## II. Project Description

| | |
|---|---|
| **Project Name:** | Backwater, Side-channel, and Riparian/Floodplain Habitat Restoration in the lower Yuba River |
| **Reference No. or New:** | New (same as submitted by FWS) |
| **Project Location:** | Lower Yuba River in the reach from the Hwy 20 bridge down to above Daguerre Point Dam. |

**Project Description:**

Rearing habitat for spring-run Chinook and steelhead in the Lower Yuba River is limited by a lack of habitat diversity and complexity owing to channel changes associated with past dredger mining activities. This project addresses the upper portion of the Yuba Goldfields where these habitat limitations are most conspicuous and the opportunities for restoration greatest. The project will build on a current AFRP-funded pilot restoration project and a conservation easement on Western Aggregates land to design and implement restoration of new functional

## II. Project Description

floodplain habitat, off-channel rearing habitat (backwaters and side-channels), large wood structure and enhanced riparian. Habitat enhancemnets will be designed to maximize extended rearing of juvenile spring-run Chinook and steelhead. The full-phase project will require excavation of dredger material suitable in both volume and quality for use by the Army Corps of Engineers in their gravel augmentation program below Englebright Dam. Thus, this project compliments the Narrows Spawning Habitat Rehabilitation project in two ways: provision of maintenance gravels and enhanced rearing habitat for expanded populations of salmon and steelhead.

## III. Species Limiting Factors

**In this section, describe the limiting factors for spring-run Chinook salmon and steelhead in your watershed. The last page of this questionnaire defines the limiting factors.**

| Limiting Factors | Description (from back page) | Rank |
|---|---|---|
| ☒ **Channel Form** | The lower Yuba River is artifically straightened and narrowed due to the management of hydraulic mining debris and dredger mining activity. | High |
| ☐ **Channel Unit Types** | | Select Rank |
| ☐ **Substrate** | | Select Rank |
| ☒ **Structure** | Large wood and riparian is conspicuously lacking in the Lower Yuba River. The technical team of fish biologists developing the Yuba Accord Fisheries Agreement identified lack of habitat complexity and diversity as one of four top stressors on Yuba River salmonid populations. This stressor is particularly important for spring-run and steelhead whose life history involves extended rearing. | High |
| ☐ **Flow** | | Select Rank |
| ☐ **Temperature** | | Select Rank |
| ☐ **Water Quality** | | Select Rank |
| ☐ **Passage** | | Select Rank |
| ☒ **Riparian/Floodplain** | Due to artificial channel confinement and a lack of riparian vegetation, populations of rearing juvenile salmonids are limited in their ability to rear past spring flows and grow at high rates. | High |

**Source Documents:**

Draft Implementation Plan for Lower Yuba River Fisheries Habitat Restoration, CVPIA 10-year Implementation Plan

**Additional Notes:**

The Yuba Accord provides flow schedules and temperature management which promises to minimize or adaptively manage the other top stressors identified for salmon and steelhead. In addition, the River Management Team is spending $0.5M annually in monitoring salmonid populations and habitat in a way that could provide evaluation for the proposed project.

## IV. Project Objectives—Environmental

**In this section, describe how your project will affect one or more of the limiting factors for spring-run Chinook salmon or steelhead described above.**

| Limiting Factor | Description and Objective | Focus |
|---|---|---|
| ☒ **Channel Form** | Create/restore a minimum of 5 acres of new backwater or side-channel habitat for rearing juvenile salmonids. | Primary |
| ☐ **Channel Unit Types** | | Select Focus |
| ☐ **Substrate** | | Select Focus |
| ☒ **Structure** | Install woody instream material and boulders within newly created backwater or side-channel habitat and at other locations in reach.. | Primary |
| ☐ **Flow** | | Select Focus |
| ☐ **Temperature** | | Select Focus |
| ☐ **Water Quality** | | Select Focus |
| ☐ **Passage** | | Select Focus |
| ☒ **Riparian/Floodplain** | Create/restore 50 acres of new functional floodplain with enhanced riparian habitat for rearing juvenile salmonids. | Primary |

## V. Project Objectives—Biological

**In this section, describe the objective(s) of your project relative to the goal of providing habitat for spring-run Chinook salmon and steelhead. Indicate the species and life stage that are targeted by the project. (It is okay to have more than one species/life stage target).**

**Target Species:** ☒ Spring-Run Chinook Salmon **Population Status Specific to Watershed:** Decreasing

**Target Life Stages:**

☐ Spawning ☐ Egg Incubation ☒ Summer Rearing ☒ Winter Rearing

☐ Juvenile Emigration ☐ Adult Immigration ☐ Adult Holding

**Description of Project Objectives:**

Enhance rearing habitat by constructing backwater and side-channels, placing wood, planting riparian and engineering restored functional floodplains. High quality rearing habitat will provide for increased growth, protection from predators, and overall increased survival of juvenile salmonids.

## V. Project Objectives—Biological

**Target Species:** ☒ Steelhead

**Population Status Specific to Watershed:** Decreasing

**Target Life Stages:**

☐ Spawning ☐ Egg Incubation ☒ Summer Rearing ☒ Winter Rearing

☐ Juvenile Emigration ☐ Adult Immigration

**Description of Project Objectives:**

Enhance rearing habitat by constructing backwater and side-channels, placing wood, planting riparian and engineering restored functional floodplains. High quality rearing habitat will provide for increased growth, protection from predators, and overall increased survival of juvenile salmonids.

## VI. Project Cost

| | |
|---|---|
| **Capital Cost:** | $2M |
| **Annual Operation and Maintenance Cost:** | $30K |
| **Annual Operation and Maintenance Description:** | Riparian enhancement and monitoring will be the primary maintenance cost to the project. The Corps is required to implement by 2012 a program of large wood supply to the lower Yuba River (NMFS 2007) |
| **Project Lifespan:** | 30 years |
| **Project Partners (Funding):** | Corps of Engineers, Western Aggregates, BLM, PG&E, USFWS Anadromous Fish Restoration Program |
| **Project Partners (Maintenance):** | Corps of Engineers, South Yuba River Citizens League |

## VII. Schedule

| | |
|---|---|
| **Proposed Start:** | 2009 |
| **Expected Time to Completion:** | 2019 |
| **Expected Time to Realize Environmental Benefits:** | 2011; full environmental benefits realized in 2019 |
| **Expected Time to Realize Biological Benefits:** | 2011; full environmental benefits realized in 2019 |

## VIII. Feasibility

| | |
|---|---|
| **Technical Feasibility:** | Pre-project assessment is underway, and conceptual designs available. Design plans alternatives and permits will need to be obtained. This type of restoration has occurred on other large Central Valley rivers. |
| **Technical Challenges:** | The Yuba River is an active channel with limitied flood management. The factors limiting recruitment and survival of riparian are still undergoing local investigation and unnatural summer hydrographs may prove problematic. |
| **Related Projects:** | Other easements and publically-owned land are likely to become available for habitat restoration projects on the Yuba River. This project compliments the Yuba Narrows Rehabilitation project by addressing limiting factors for juvenile rearing and providing a source for the maintenance of gravels. |
| **Ownership or Permitting Challenges:** | Western Aggregates has made 3 miles of the south bank a conservation easement for the purpose of habitat restoration. BLM manages the Hammon tract and is an cooperative partner. A small tract of Army Corps land exists between. Corps permits will be needed. |
| **Conflicts with Cultural, Zoning, or Other Issues:** | None determined |

## IX. Project Support

| | |
|---|---|
| **Supporting Entities:** | SYRCL, FWS, BLM, Western Aggregates |
| **Cooperating Entities:** | DFG and NMFS |
| **Degree of Local Support:** | SYRCL has been conducting outreach activities to inform the public about this project and encountered a high degree of support |
| **Known Opposition:** | None determined. |

## X. Supporting Documents

**Please provide a full reference for each citation used to support the information presented in this questionnaire.**


SYRCL (2008) A Framework for Restoration in the Lower Yuba River

Draft Implementation Plan for Lower Yuba River Anadromous Fish Habitat Restoration. October 2005. Lower Yuba River Fisheries Technical Working Group. CD Distribution

NMFS BiOp on Englebright and Daguerre Dams (2007)

## Definitions of Limiting Factors for Spring-Run Chinook Salmon and Steelhead

### Channel Form

This attribute describes changes to the channel, including incision, aggradation, diking, armoring, and other modifications of the channel adversely affecting spring-run Chinook salmon and steelhead.

### Channel Unit Types

Examples of geomorphic features of the channel that form habitat types for spring-run Chinook salmon and steelhead are pools, riffles, glides, and runs. This attribute describes changes in the frequency and size of such features. For example, removal of large wood may reduce the frequency of pools, presence of steps, or retention of gravel for riffles.

### Substrate

This attribute describes changes in the composition of the substrate of the stream, including increase in fine sediment and lack of gravel recruitment.

### Structure

This attribute describes the loss of structural elements in the stream such as large wood, boulders, undercut banks, and so on. Loss of structure results in a simplification of the channel and influences Channel Form and Channel Unit Types.

### Flow

This attribute addresses modification of the flow regime, including decrease in summer low flow, increased "flashiness," and dewatering of the channel as a result of withdrawals.

### Temperature

Change in water temperature can be attributable to human actions such as removal of riparian shading. This attribute describes the increase in summer water temperature and the loss of temperature refugia (springs or groundwater) as a result of human actions.

### Water Quality

This attribute pertains to the input to the stream of toxins or pollutants that produce adverse impacts on spring-run Chinook salmon or steelhead. This can include chemical pollutants such as fertilizer and pesticides and nutrient sources such as cattle and feedlots.

### Passage

This relates to the effect of impediments to adult or juvenile migration of spring-run Chinook salmon or steelhead, including dams, culverts, channel dewatering, and other structural and channel modifications. Please describe the location of the passage impediment and describe the extent of impediment (i.e., a complete or partial blockage to migration).

### Riparian/Floodplain

This attribute describes the loss of functionality of the riparian forest/vegetation and the connection of the stream to the floodplain during high water and flooding.

## Population Condition Definitions for Section V. Project Objectives—Biological

### Increasing

Adult returns of the target species to the watershed have generally been increasing over the last several years; expectations are that the species is displaying characteristics of a rebuilding or healthy population.

### Stable

Adult returns of the target species to the watershed show no clear trend over the last several years.

### Decreasing

Adult returns of the target species to the watershed are declining over the last several years; the decline in abundance is a cause of concern and characteristic of a potentially unhealthy population.

### Intermittent

Adult returns of the target species are occasionally seen in the watershed, but there is no viable or sustained population in the basin.

### Extirpated

The population has been eliminated from the watershed although the species was present in the past.

### Never Present

The species has never been known to occur in the watershed.

# Questionnaire

for

# Information on Potential Projects to Support Spring-Run Chinook Salmon and Steelhead in the Sacramento River Basin for the Habitat Expansion Agreement

**DUE: Friday, February 27, 2009**

**Send completed questionnaires to hea@water.ca.gov**

## I. Contact Information

| | |
|---|---|
| **Name:** | Beth Campbell |
| **Organization:** | USFWS |
| **Address:** | Stockton FWO<br>4001 North Wilson Way |
| **City, State, Zip Code:** | Stockton, CA 95205 |
| **Phone Number:** | (209) 334-2968 ext 402 |
| **Email Address:** | elizabeth_campbell@fws.gov |

## II. Project Description

| | |
|---|---|
| **Project Name:** | Yuba River Narrows Habitat Enhancement |
| **Reference No. or New:** | New |
| **Project Location:** | Yuba River (Narrows Reach is about 10 miles upstream from Daguerre Point Dam) |

**Project Description:**

Spawning gravel is abundant in much of the lower Yuba River due to continual inputs from historical mine tailings. In the Narrows reach where spring-run Chinook salmon hold, however, gravel augmentation is needed. Spring-run chinook salmon in fact have been observed attempting to spawn on bedrock. This project would provide for the removal of undesirable "shot rock" and install spawning gravel usable by spring-run Chinook salmon and steelhead.

## III. Species Limiting Factors

**In this section, describe the limiting factors for spring-run Chinook salmon and steelhead in your watershed. The last page of this questionnaire defines the limiting factors.**

| Limiting Factors | Description (from back page) | Rank |
|---|---|---|
| ☐ **Channel Form** | | Select Rank |
| ☐ **Channel Unit Types** | | Select Rank |
| ☒ **Substrate** | Insufficent gravel for spawning is available in the Narrows reach of the Yuba River where many spring-run Chinook salmon hold and attempt to spawn. | High |
| ☐ **Structure** | | Select Rank |
| ☐ **Flow** | | Select Rank |
| ☐ **Temperature** | | Select Rank |
| ☐ **Water Quality** | | Select Rank |
| ☐ **Passage** | | Select Rank |
| ☐ **Riparian/Floodplain** | | Select Rank |

**Source Documents:**

CVPIA 10-year Implementation Plan

**Additional Notes:**

## IV. Project Objectives—Environmental

**In this section, describe how your project will affect one or more of the limiting factors for spring-run Chinook salmon or steelhead described above.**

| Limiting Factor | Description and Objective | Focus |
|---|---|---|
| ☐ **Channel Form** | | Select Focus |
| ☐ **Channel Unit Types** | | Select Focus |
| ☒ **Substrate** | Restore 1 acre of salmonid spawning habitat in the Narrows reach of the Yuba River. | Primary |
| ☐ **Structure** | | Select Focus |
| ☐ **Flow** | | Select Focus |
| ☐ **Temperature** | | Select Focus |
| ☐ **Water Quality** | | Select Focus |
| ☐ **Passage** | | Select Focus |

## IV. Project Objectives—Environmental

☐ **Riparian/Floodplain** Select Focus

## V. Project Objectives—Biological

**In this section, describe the objective(s) of your project relative to the goal of providing habitat for spring-run Chinook salmon and steelhead. Indicate the species and life stage that are targeted by the project. (It is okay to have more than one species/life stage target).**

**Target Species:** ☒ Spring-Run Chinook Salmon **Population Status Specific to Watershed:** Decreasing

**Target Life Stages:**

☒ Spawning ☐ Egg Incubation ☐ Summer Rearing ☐ Winter Rearing

☐ Juvenile Emigration ☐ Adult Immigration ☐ Adult Holding

**Description of Project Objectives:**

Increase the availability of suitable spawning habitat in the Narrows reach of the Yuba River, to provide for increased spawning success of spring-run Chinook salmon.

**Target Species:** ☒ Steelhead **Population Status Specific to Watershed:** Decreasing

**Target Life Stages:**

☒ Spawning ☐ Egg Incubation ☐ Summer Rearing ☐ Winter Rearing

☐ Juvenile Emigration ☐ Adult Immigration

**Description of Project Objectives:**

Increase the availability of suitable spawning habitat in the Narrows reach of the Yuba River, to provide for increased spawning success of steelhead.

## VI. Project Cost

| | |
|---|---|
| **Capital Cost:** | $300K |
| **Annual Operation and Maintenance Cost:** | $30K |
| **Annual Operation and Maintenance Description:** | Ongoing gravel augmentation. |
| **Project Lifespan:** | 30 years |
| **Project Partners (Funding):** | Corps of Engineers, PG&E |
| **Project Partners** | Corps of Engineers |

## VI. Project Cost

**(Maintenance):**

## VII. Schedule

| | |
|---|---|
| **Proposed Start:** | 2010 |
| **Expected Time to Completion:** | 2012 |
| **Expected Time to Realize Environmental Benefits:** | 2012 |
| **Expected Time to Realize Biological Benefits:** | 2012 |

## VIII. Feasibility

| | |
|---|---|
| **Technical Feasibility:** | Design plans are needed and permits will need to be obtained. |
| **Technical Challenges:** | The Yuba River can be a very active river channel |
| **Related Projects:** | The Corps of Engineers is required to do this as part of the NMFS (2002) BO. The Corps funding requirement should be clearly identified, before being supplemented with HEA funds. |
| **Ownership or Permitting Challenges:** | Easiest access to a likely site (PG&E mitigation land) is across private land, and landowner support has been inconsistent. DFG is not a proponent of allowing heavy equipment into the stream channel. |
| **Conflicts with Cultural, Zoning, or Other Issues:** | None |

## IX. Project Support

| | |
|---|---|
| **Supporting Entities:** | FWS and NMFS |
| **Cooperating Entities:** | DFG |
| **Degree of Local Support:** | Yuba County Resource Conservation District is a proponent of this project. |
| **Known Opposition:** | See ownership or permitting challenges, above. |

## X. Supporting Documents

**Please provide a full reference for each citation used to support the information presented in this questionnaire.**

## Definitions of Limiting Factors for Spring-Run Chinook Salmon and Steelhead

### Channel Form

This attribute describes changes to the channel, including incision, aggradation, diking, armoring, and other modifications of the channel adversely affecting spring-run Chinook salmon and steelhead.

### Channel Unit Types

Examples of geomorphic features of the channel that form habitat types for spring-run Chinook salmon and steelhead are pools, riffles, glides, and runs. This attribute describes changes in the frequency and size of such features. For example, removal of large wood may reduce the frequency of pools, presence of steps, or retention of gravel for riffles.

### Substrate

This attribute describes changes in the composition of the substrate of the stream, including increase in fine sediment and lack of gravel recruitment.

### Structure

This attribute describes the loss of structural elements in the stream such as large wood, boulders, undercut banks, and so on. Loss of structure results in a simplification of the channel and influences Channel Form and Channel Unit Types.

### Flow

This attribute addresses modification of the flow regime, including decrease in summer low flow, increased "flashiness," and dewatering of the channel as a result of withdrawals.

### Temperature

Change in water temperature can be attributable to human actions such as removal of riparian shading. This attribute describes the increase in summer water temperature and the loss of temperature refugia (springs or groundwater) as a result of human actions.

### Water Quality

This attribute pertains to the input to the stream of toxins or pollutants that produce adverse impacts on spring-run Chinook salmon or steelhead. This can include chemical pollutants such as fertilizer and pesticides and nutrient sources such as cattle and feedlots.

### Passage

This relates to the effect of impediments to adult or juvenile migration of spring-run Chinook salmon or steelhead, including dams, culverts, channel dewatering, and other structural and channel modifications. Please describe the location of the passage impediment and describe the extent of impediment (i.e., a complete or partial blockage to migration).

### Riparian/Floodplain

This attribute describes the loss of functionality of the riparian forest/vegetation and the connection of the stream to the floodplain during high water and flooding.

## Population Condition Definitions for Section V. Project Objectives—Biological

### Increasing

Adult returns of the target species to the watershed have generally been increasing over the last several years; expectations are that the species is displaying characteristics of a rebuilding or healthy population.

### Stable

Adult returns of the target species to the watershed show no clear trend over the last several years.

### Decreasing

Adult returns of the target species to the watershed are declining over the last several years; the decline in abundance is a cause of concern and characteristic of a potentially unhealthy population.

### Intermittent

Adult returns of the target species are occasionally seen in the watershed, but there is no viable or sustained population in the basin.

### Extirpated

The population has been eliminated from the watershed although the species was present in the past.

### Never Present

The species has never been known to occur in the watershed.

# Questionnaire

for

# Information on Potential Projects to Support Spring-Run Chinook Salmon and Steelhead in the Sacramento River Basin for the Habitat Expansion Agreement

**DUE: Thursday, April 30, 2009**

**Send completed questionnaires to hea@water.ca.gov**

## I. Contact Information

| | |
|---|---|
| **Name:** | Duane Massa |
| **Organization:** | CA. Dept. of Fish and Game |
| **Address:** | 2545 Zanella Wy. Suite F |
| **City, State, Zip Code:** | Chico, CA 95928 |
| **Phone Number:** | (530) 895-5005 |
| **Email Address:** | dmassa@dfg.ca.gov |

## II. Project Description

| | |
|---|---|
| **Project Name:** | Lower Yuba River Narrows Gravel Rehabilitation Project |
| **Reference No. or New:** | |
| **Project Location:** | The Narrows reach is an approximately a six-mile span of potentially high quality spring-run Chinook salmon spawning habitat located on the lower Yuba River from Englebright Dam to the State Route 20 Bridge in Yuba County, CA. |

**Project Description:**

Englebright Dam was constructed in 1941 on the lower Yuba River to trap hyrdaulic mining debris left from the gold rush in California. The dam has been blocking the natural recruitment of spawning gravels in the Narrows reach for over 65 years. In many areas of this reach, the spawning gravels are completely absent and have been replaced by a bedrock substrate. Spring-run Chinook salmon have been observed to migrate and hold in this area of river, but spawning success has been largely impacted by a lack of suitable spawning substrate as a result of gravel impoundment at Englebright Dam. Gravel injection at this site is expected to expand available spawning habitat primarily for spring-run Chinook salmon, as suitable flow regimes already exist. A pilot gravel injection project

## II. Project Description

was successfully completed in the Narrows reach during November 2007. Approximately 361 cubic yards of spawning gravels were injected below the Narrows II powerhouse. Aerial redd surveys conducted in 2008 positively identified spring-run Chinook salmon utilizing the pockets of gravel created by this pilot project. However, additional gravels are needed to fully rehabilitate this reach. This can be accomplished through the injection of approximately 54,000 cubic yards of gravel in the Narrows reach (Englebright-SR20) over several years. Preliminary estimates of this river section indicate that this activity can provide additional spawning habitat for over 4,850 spring-run Chinook salmon.

## III. Species Limiting Factors

**In this section, describe the limiting factors for spring-run Chinook salmon and steelhead in your watershed. The last page of this questionnaire defines the limiting factors.**

| Limiting Factors | Description (from back page) | Rank |
|---|---|---|
| ☒ **Channel Form** | Channel incision and slope have been affected by land use, hydraulic mining and hydropower practices. | High |
| ☒ **Channel Unit Types** | Natural channel morphological units have been altered by land use, hydraulic mining and hydropower practices. | High |
| ☒ **Substrate** | Spawning gravel substrate has been completely lost in many sections of the lower Yuba River due to impoundment by Englebright Dam. | Critical |
| ☒ **Structure** | Natural channel form and unit types synonomous with spawning habitat values (i.e. pool, riffle, bank structure, LWD retention, etc.) have been altered by land use, hydraulic mining and hydropower practices. | High |
| ☐ **Flow** | | Select Rank |
| ☐ **Temperature** | | Select Rank |
| ☐ **Water Quality** | | Select Rank |
| ☒ **Passage** | Englebright Dam blocks access to the majority of historic spring-run Chinook salmon spawning habitat. Daguerre Point Dam creates passage difficulties for both adult and juvenile salmonids. | High |
| ☐ **Riparian/Floodplain** | | Select Rank |

**Source Documents:**

Pasternack, Greg. 2009. SHIRA-based river analysis and field-based manipulative sediment transport experiments to balance habitat and geomorphic goals on the lower Yuba River. Final Report. U.C. Davis Cooperative Ecosystems Studies Unit

Available from http://pasternack.ucdavis.edu/LYR3_Pasternack_FINAL.pdf

**Additional Notes:**

## III. Species Limiting Factors

## IV. Project Objectives—Environmental

**In this section, describe how your project will affect one or more of the limiting factors for spring-run Chinook salmon or steelhead described above.**

| Limiting Factor | Description and Objective | Focus |
|---|---|---|
| ☒ **Channel Form** | Gravel injection will decrease channel incision and restore natural slope, thus serving to self-regulate additional gravel loss. | Secondary |
| ☒ **Channel Unit Types** | Gravel injection will improve spawning habitat by restoring natual channel morphological units. | Secondary |
| ☒ **Substrate** | Gravel injection will restore natural spawning substrate absent in this reach. | Primary |
| ☒ **Structure** | Gravel injection will restore natural channel form and unit types synonomous with spawning habitat values (i.e. pool, riffle, bank structure, LWD retention, etc.). | Primary |
| ☐ **Flow** | | Select Focus |
| ☐ **Temperature** | | Select Focus |
| ☐ **Water Quality** | | Select Focus |
| ☐ **Passage** | | Select Focus |
| ☐ **Riparian/Floodplain** | | Select Focus |

## V. Project Objectives—Biological

**In this section, describe the objective(s) of your project relative to the goal of providing habitat for spring-run Chinook salmon and steelhead. Indicate the species and life stage that are targeted by the project. (It is okay to have more than one species/life stage target).**

**Target Species:** ☒ Spring-Run Chinook Salmon **Population Status Specific to Watershed:** Stable

**Target Life Stages:**

☒ Spawning ☒ Egg Incubation ☒ Summer Rearing ☒ Winter Rearing

☐ Juvenile Emigration ☐ Adult Immigration ☒ Adult Holding

**Description of Project Objectives:**

The objective of this project is to restore gravel recruitment below Englebright Dam. This process is a critical step to restoring historic spring-run Chinook salmon populations on the lower Yuba River. Gravel injection will serve to restore historic spawning areas currently under-utilized. This process will also serve to restore several other natural river channel unit, form and structural functions; including a reduction of channel incision, restoration of natural

## V. Project Objectives—Biological

slope for gravel retention, and restoration of natural pool/run/riffle mesohabitat interactions.

**Target Species:** ☒ Steelhead

**Population Status Specific to Watershed:** Stable

**Target Life Stages:**

☒ Spawning ☒ Egg Incubation ☒ Summer Rearing ☒ Winter Rearing

☐ Juvenile Emigration ☐ Adult Immigration

**Description of Project Objectives:**

Steelhead escapement to the lower Yuba River is currently unknown, but monitoring activities have observed adult and juvenile steelhead to be present. Adult spawning activity and yearly emigrations have been observed. Restoration of historic spawning areas will likely improve habitat conditions for this species.

## VI. Project Cost

| | |
|---|---|
| **Capital Cost:** | $3,000,000 (estimated) for initial 54,000 cu yards |
| **Annual Operation and Maintenance Cost:** | Unknown |
| **Annual Operation and Maintenance Description:** | Annual replentishment of gravel substrate will be necessary for the period that Englebright Dam blocks natural downstream gravel movement. |
| **Project Lifespan:** | The project would have a lifespan corresponding with the continued operation of Englebright Dam. |
| **Project Partners (Funding):** | Unknown |
| **Project Partners (Maintenance):** | Unknown |

## VII. Schedule

| | |
|---|---|
| **Proposed Start:** | Once permits and funding are secured (possibly November 2009). |
| **Expected Time to Completion:** | One month |
| **Expected Time to Realize Environmental Benefits:** | Immediate |
| **Expected Time to Realize Biological Benefits:** | Immediate |

## VIII. Feasibility

| | |
|---|---|
| **Technical Feasibility:** | A pilot gravel injection project was successfully completed in November 2007. |
| **Technical Challenges:** | None. All were addressed during pilot project activities. |
| **Related Projects:** | A number of restoration projects are in various stages of completion to address passage, spawning and rearing components of a complete river rehabilitation. |
| **Ownership or Permitting Challenges:** | The property is owned jointly by PGE, YCWA and USACE. Permits were successfully acquired for the pilot project. No significant challenges forseen. |
| **Conflicts with Cultural, Zoning, or Other Issues:** | None identified at this time. |

## IX. Project Support

| | |
|---|---|
| **Supporting Entities:** | U.C. Davis, NMFS, USFWS, USACE, CDFG, PGEYCWA, Yuba River Accord Management Team, Yuba River Technical Working Group, South Yuba River Citizens League |
| **Cooperating Entities:** | U.C. Davis, NMFS, USFWS, USACE, CDFG, PGE, YCWA |
| **Degree of Local Support:** | High at this time. |
| **Known Opposition:** | None identified at this time. |

## X. Supporting Documents

**Please provide a full reference for each citation used to support the information presented in this questionnaire.**

Pasternack, Greg. 2009. SHIRA-based river analysis and field-based manipulative sediment transport experiments to balance habitat and geomorphic goals on the lower Yuba River. Final Report. U.C. Davis Cooperative Ecosystems Studies Unit

Available from http://pasternack.ucdavis.edu/LYR3_Pasternack_FINAL.pdf.

## Definitions of Limiting Factors for Spring-Run Chinook Salmon and Steelhead

### Channel Form

This attribute describes changes to the channel, including incision, aggradation, diking, armoring, and other modifications of the channel adversely affecting spring-run Chinook salmon and steelhead.

### Channel Unit Types

Examples of geomorphic features of the channel that form habitat types for spring-run Chinook salmon and steelhead are pools, riffles, glides, and runs. This attribute describes changes in the frequency and size of such features. For example, removal of large wood may reduce the frequency of pools, presence of steps, or retention of gravel for riffles.

### Substrate

This attribute describes changes in the composition of the substrate of the stream, including increase in fine sediment and lack of gravel recruitment.

### Structure

This attribute describes the loss of structural elements in the stream such as large wood, boulders, undercut banks, and so on. Loss of structure results in a simplification of the channel and influences Channel Form and Channel Unit Types.

### Flow

This attribute addresses modification of the flow regime, including decrease in summer low flow, increased "flashiness," and dewatering of the channel as a result of withdrawals.

### Temperature

Change in water temperature can be attributable to human actions such as removal of riparian shading. This attribute describes the increase in summer water temperature and the loss of temperature refugia (springs or groundwater) as a result of human actions.

### Water Quality

This attribute pertains to the input to the stream of toxins or pollutants that produce adverse impacts on spring-run Chinook salmon or steelhead. This can include chemical pollutants such as fertilizer and pesticides and nutrient sources such as cattle and feedlots.

### Passage

This relates to the effect of impediments to adult or juvenile migration of spring-run Chinook salmon or steelhead, including dams, culverts, channel dewatering, and other structural and channel modifications. Please describe the location of the passage impediment and describe the extent of impediment (i.e., a complete or partial blockage to migration).

### Riparian/Floodplain

This attribute describes the loss of functionality of the riparian forest/vegetation and the connection of the stream to the floodplain during high water and flooding.

## Population Condition Definitions for Section V. Project Objectives—Biological

### Increasing

Adult returns of the target species to the watershed have generally been increasing over the last several years; expectations are that the species is displaying characteristics of a rebuilding or healthy population.

### Stable

Adult returns of the target species to the watershed show no clear trend over the last several years.

### Decreasing

Adult returns of the target species to the watershed are declining over the last several years; the decline in abundance is a cause of concern and characteristic of a potentially unhealthy population.

### Intermittent

Adult returns of the target species are occasionally seen in the watershed, but there is no viable or sustained population in the basin.

### Extirpated

The population has been eliminated from the watershed although the species was present in the past.

### Never Present

The species has never been known to occur in the watershed.

# Questionnaire

for

# Information on Potential Projects to Support Spring-Run Chinook Salmon and Steelhead in the Sacramento River Basin for the Habitat Expansion Agreement

## DUE: Thursday, April 30, 2009

## Send completed questionnaires to hea@water.ca.gov

## I. Contact Information

| | |
|---|---|
| **Name:** | Gary Reedy |
| **Organization:** | South Yuba River Citizens League |
| **Address:** | 217 Main Street |
| **City, State, Zip Code:** | Nevada City, Ca 95959 |
| **Phone Number:** | 530.265.5961 x208 |
| **Email Address:** | gary@syrcl.org |

## II. Project Description

| | |
|---|---|
| **Project Name:** | Yuba River Narrows Spawning Habitat Rehabilitation |
| **Reference No. or New:** | Basically, same as "Narrows Rehabilitation" project submitted by CDFG and FWS |
| **Project Location:** | Yuba River (0.8 miles below Englebright and immediately upstream of Deer Creek)<br>39deg 13' 50 N 121deg 16' 37 W |

**Project Description:**

Compared to historic conditions, spring-run Chinook and steelhead populations of the Yuba River are severely limited by blockage from Englebright Dam. The spring-run Chinook population of the Yuba River is at high risk of extinction due to average annual abundance <500 fish, strays from the Feather River Hatchery and inadequate spawning segregation from the fall-run population. This project would restore habitat in the reach below Englebright Dam where spring-run Chinook are known to hold and attempt spawning despite a lack of suitable spawning habitat. This project may also involve a segregation weir approximately 6 miles below Englebright to provide spawning segregation from non-natal and fall-run salmon. The need and benefits for the segregation weir

## II. Project Description

component of the project can be more completely evaluated following results from ongoing studies by the Yuba Accord RMT involving tagging, tracking, redd mapping and genetic analysis. Dr. Greg Pasternak of UC Davis has thoroughly described the physical situation in the Englebright Dam Reach (EDR). Although the Armcy Corps of Engineers is required to implement a gravel augmentation program, no such program will provide benefits to salmon and steelhead until the channel is rehabilitated from instream gravel mining and deposition of shot rock. With rehabilitation and the provision of 100,000 tons of gravel, the Englebright Dam Reach could support at least 2000 spawning spring-run Chinook. Gravel supply would then be maintained as per requirements of the Corps. The benefits of this project, for steelhead in particular, would be expanded with gravel augmentation in Deer Creek which enters the reach near the location of highest potential for spawning habitat enhancement.

## III. Species Limiting Factors

**In this section, describe the limiting factors for spring-run Chinook salmon and steelhead in your watershed. The last page of this questionnaire defines the limiting factors.**

| Limiting Factors | Description (from back page) | Rank |
|---|---|---|
| ☒ **Channel Form** | Instream gravel mining and deposition of shot rock has made the channel at the project location unsuitable for spawning, even with restoration of annual gravel supply. More generally, the channel form in the lower Yuba is affected by lack of gravel supply in upper reach (i.e. downcutting) and artificial confinement from RM 7 to RM 21 (goldfields) resulting from walls of mine tailings. | High |
| ☐ **Channel Unit Types** | | Select Rank |
| ☒ **Substrate** | Englebright Dam blocks transport of all gravels into the channel below. Spawning habitat exists beginning two miles below the dam as material becomes entrained from historic terraces and mine tailings | High |
| ☒ **Structure** | see note below | Medium |
| ☐ **Flow** | | Select Rank |
| ☐ **Temperature** | | Select Rank |
| ☐ **Water Quality** | | Select Rank |
| ☒ **Passage** | Englebright Dam blocks access to the majority of spawning habitat in the watershed for spring-run and steelhead; No segregation provided for spawning of spring-run. | High |
| ☒ **Riparian/Floodplain** | see note below | Medium |

**Source Documents:**

Pasternack Manuscript on Englebright Dam Reach, Draft Implemention Plan for Lower Yuba River Anadromous Fish Restoration, Recovery Plan for Central Valley Spring-run Chinook and Steelhead (Co-manager Draft).

**Additional Notes:**

For description and sources for structure and riparian/floodplain as limiting factors in the lower Yuba River, see submitted information for Yuba River Rearing Habitat Enhancement

## IV. Project Objectives—Environmental

**In this section, describe how your project will affect one or more of the limiting factors for spring-run Chinook salmon or steelhead described above.**

| Limiting Factor | Description and Objective | Focus |
|---|---|---|
| ☒ **Channel Form** | Rehabilitation of channel form by shot rock removal and regrading as necessitated following final analysis of alternatives | Primary |
| ☐ **Channel Unit Types** | | Select Focus |
| ☒ **Substrate** | Placement of 100,000 tons of spawning gravel to be followed by program of gravel augmentation/maintenance by the Army Corps | Primary |
| ☒ **Structure** | Through association with Yuba River Rearing Enhancement Project | Secondary |
| ☐ **Flow** | | Select Focus |
| ☐ **Temperature** | | Select Focus |
| ☐ **Water Quality** | | Select Focus |
| ☒ **Passage** | Through association with Deer Creek Gravel Augmentation and Passage Project submitted by Friends of Deer Creek | Secondary |
| ☒ **Riparian/Floodplain** | Through association with Yuba River Rearing Enhancement Project | Secondary |

## V. Project Objectives—Biological

**In this section, describe the objective(s) of your project relative to the goal of providing habitat for spring-run Chinook salmon and steelhead. Indicate the species and life stage that are targeted by the project. (It is okay to have more than one species/life stage target).**

**Target Species:** ☒ Spring-Run Chinook Salmon **Population Status Specific to Watershed:** Decreasing

**Target Life Stages:**

☒ Spawning ☒ Egg Incubation ☒ Summer Rearing ☐ Winter Rearing

☐ Juvenile Emigration ☐ Adult Immigration ☐ Adult Holding

**Description of Project Objectives:**

Provide spawning habitat in the Englebright Dam Reach of the Yuba River to support 2000 or more spring-run Chinook salmon and enhance juvenile productivity. Also, to provide spatial segregation during spawning from summer immigrants and fall-run Chinook as needed to protect phenotypically or genetically distinct spring-run Chinook. Note: Based on results from gravel placement in Mokelumne River (Joe Merz, personal communication), 100,000 tons of gravel could be sufficient to support this spawning population and greatly enhance production of macroinvertebrates representing food sources for juvenile salmonids.

## V. Project Objectives—Biological

**Target Species:** ☒ Steelhead

**Population Status Specific to Watershed:** Decreasing

**Target Life Stages:**

☒ Spawning ☒ Egg Incubation ☐ Summer Rearing ☐ Winter Rearing

☐ Juvenile Emigration ☐ Adult Immigration

**Description of Project Objectives:**

Increase the availability of suitable spawning and incubation habitat in the Narrows reach of the Yuba River, to provide for increased spawning success and juvenile productivity for steelhead. Also, this project is complimentary with gravel augmentation in Deer Creek (as proposed by Friends of Deer Creek) which could provide additional benefits in the confluence area for both species and more than 4 miles of expanded spawning and rearing for steelhead.

## VI. Project Cost

| | |
|---|---|
| **Capital Cost:** | $3.1M for habitat rehabilitation (based on $30/ton placed gravel plus engineering and design), plus $ 219,000 for weir |
| **Annual Operation and Maintenance Cost:** | $52,000 annually for weir operation and monitoring |
| **Annual Operation and Maintenance Description:** | The Corps is obligated to provide sufficient gravel to channel below Englebright to maintain habitat at no cost to project (estimated by Pasternak to be 10,000 tons). Segregation weir would involve full-time staff for 3.5 months/year plus assembly and disassembly. |
| **Project Lifespan:** | 30 years |
| **Project Partners (Funding):** | PG&E (tbd per Narrows Mitigation Fund), FWS (AFRP) |
| **Project Partners (Maintenance):** | Army Corps (tbd for gravel augmentation/maintenance); Yuba County Water Agency (tbd for support of weir and monitoring) |

## VII. Schedule

| | |
|---|---|
| **Proposed Start:** | 2010 |
| **Expected Time to Completion:** | 2 months for construction period |
| **Expected Time to Realize Environmental Benefits:** | 2011 |
| **Expected Time to Realize Biological Benefits:** | 2011 |

## VIII. Feasibility

| | |
|---|---|
| **Technical Feasibility:** | Similar spawning habitat rehabilitation has been conducted in the Central Valley, including on the Mokelumne and Tuolomne Rivers. Resistance board segregation weirs are versatile and used by fisheries managers throughout the region. Cramer Fish Sciences staff, who pioneered the use the technology in California, has provided reconnaissance and confirmed feasibility on the Yuba River. For more information, see their resistance board weir website at http://weir.fishsciences.net. |
| **Technical Challenges:** | The Yuba River has limited flood control above Englebright and constructed spawning channels will be subject to scouring forces. Additional analysis is required to determine appropriate site rehabilitation techniques before gravel placement. For example, complete shot rock removal may not be required. Also, shot rock near the dam must be stabilized to prevent future impacts. |
| **Related Projects:** | Gravel augmentation proposed by Friends of Deer Creek would add substantially to the amount of expanded steelhead habitat in this area. Restoration of off-channel rearing habitat in the Parks Bar to Hammon reach of the Yuba River (as proposed by USFWS and SYRCL) would address a limiting factor for spring-run Chinook and steelhead juveniles. The Corps of Engineers is required by a NMFS BiOp to implement a program of gravel augmentation by the fall of 2012. However, this program is not likely to start before site rehabilitation for which no entity has been made responsible. Nevertheless, the Corps program should be solidified before completion of this project. |
| **Ownership or Permitting Challenges:** | Access to rehabilitation site requires either permission from two private landowners so far offering less than consistent support, or construction of road on steep slopes of PG&E mitigation land. CDFG has expressed concerns about the new road and immediate impacts of the project on holding spring-run salmon. |
| **Conflicts with Cultural, Zoning, or Other Issues:** | None determined |

## IX. Project Support

| | |
|---|---|
| **Supporting Entities:** | FWS, CDFG, NMFS, SYRCL; PG&E support to be determined. |
| **Cooperating Entities:** | Friends of Deer Creek, UC Field Station; Yuba County Water Agency cooperation to be determined. |
| **Degree of Local Support:** | Yuba County Resource Conservation District has proposed a pilot phase of this project for funding by the Sierra Nevada Conservancy. This project is expected to have a high degree of local support because it recovers spring-run and steelhead populations without altering water management, recreation or access. If used, a segregation weir would block only the relatively small portion of salmon attempting to migrate into the upper reach from July 1 to October 15. |
| **Known Opposition:** | The segregation weir component will have opposition without data to demonstrate lack of sufficient natural segregation. One of two immediate landowners in the rehab location may prove oppositional. |

## X. Supporting Documents

**Please provide a full reference for each citation used to support the information presented in this questionnaire.**


Pasternack and others, Manuscript 2009, Historical Analysis of the Englebright Dam Reach of the Lower Yuba River, CA to Aid Spring-run Chinook Salmon Habitat Rehabilitation.

Shira-based river analysis and field-based manipulative sediment transport experiments to balance habitat and geomorphic goals on the Lower Yuba River. http://pasternack.ucdavis.edu/LYR3_Pasternack_FINAL.pdf

NMFS, Central Valley Spring-run and steelhead recovery plan (co-manager draft)

Draft Implementation Plan for Lower Yuba River Anadromous Fish Habitat Restoration. October 2005. Lower Yuba River Fisheries Technical Working Group. CD Distribution

Merz JE, Ochikubo Chan LK. 2005. Effects of gravel augmentation on macroinvertebrate assemblages in a regulated California river. River Research and Applications 21: 61–74. DOI: 10.1002/rra.819

Merz JE, Setka JD, Pasternack GB, Wheaton JM. 2004. Predicting benefits of spawning habitat rehabilitation to salmonid fry production in a regulated California river. Canadian Journal of Fisheries and Aquatic Science 61: 1433–1446. DOI: 10.1577/M03-038.1

## Definitions of Limiting Factors for Spring-Run Chinook Salmon and Steelhead

### Channel Form

This attribute describes changes to the channel, including incision, aggradation, diking, armoring, and other modifications of the channel adversely affecting spring-run Chinook salmon and steelhead.

### Channel Unit Types

Examples of geomorphic features of the channel that form habitat types for spring-run Chinook salmon and steelhead are pools, riffles, glides, and runs. This attribute describes changes in the frequency and size of such features. For example, removal of large wood may reduce the frequency of pools, presence of steps, or retention of gravel for riffles.

### Substrate

This attribute describes changes in the composition of the substrate of the stream, including increase in fine sediment and lack of gravel recruitment.

### Structure

This attribute describes the loss of structural elements in the stream such as large wood, boulders, undercut banks, and so on. Loss of structure results in a simplification of the channel and influences Channel Form and Channel Unit Types.

### Flow

This attribute addresses modification of the flow regime, including decrease in summer low flow, increased "flashiness," and dewatering of the channel as a result of withdrawals.

### Temperature

Change in water temperature can be attributable to human actions such as removal of riparian shading. This attribute describes the increase in summer water temperature and the loss of temperature refugia (springs or groundwater) as a result of human actions.

### Water Quality

This attribute pertains to the input to the stream of toxins or pollutants that produce adverse impacts on spring-run Chinook salmon or steelhead. This can include chemical pollutants such as fertilizer and pesticides and nutrient sources such as cattle and feedlots.

### Passage

This relates to the effect of impediments to adult or juvenile migration of spring-run Chinook salmon or steelhead, including dams, culverts, channel dewatering, and other structural and channel modifications. Please describe the location of the passage impediment and describe the extent of impediment (i.e., a complete or partial blockage to migration).

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# Questionnaire

for

# Information on Potential Projects to Support Spring-Run Chinook Salmon and Steelhead in the Sacramento River Basin for the Habitat Expansion Agreement

**DUE: Thursday, April 30, 2009**

**Send completed questionnaires to hea@water.ca.gov**

## I. Contact Information

| | |
|---|---|
| **Name:** | Joanne Hild |
| **Organization:** | Friends of Deer Creek |
| **Address:** | 132 Main Street |
| **City, State, Zip Code:** | Nevada City, CA 95959 |
| **Phone Number:** | 530-265-6090 |
| **Email Address:** | joanne@friendsofdeercreek.org |

## II. Project Description

| | |
|---|---|
| **Project Name:** | Deer Creek Salmon and Steelhead Spawning Habitat Expansion Project |
| **Reference No. or New:** | |
| **Project Location:** | Deer Creek between Lake Wildwood and the confluence with the Yuba River. 39.2358 deg N; 121.2190 deg W at the Lake Wildwood dam. |

**Project Description:**

The Deer Creek Salmon and Steelhead Habitat Expansion Project is an effort to restore critical habitat for Spring-run Chinook salmon and steelhead through a combination of targeted gravel augmentation, barrier removal, invasive species removal, riparian revegetation, and collaboration with affected stakeholders, especially Lake Wildwood. In August 2008 the California Department of Fish and Game included Deer Creek on its list of 22 priority streams for future instream work. The list was compiled and ranked based on input from Regional DFG staff, staff from the State Water Board, U.S. Fish and Wildlife Service, and the National Marine Fisheries Service, using the following criteria: 1) Presence of anadromous species; 2) likelihood that DFG flow recommendations would provide a high level of improvement; 3) availability of recent flow studies or other relevant data; and 4) the possibility of

## II. Project Description

partners/willing landowners. This proposal is offered in conjunction with the Yuba River Narrows Spawning Habitat Rehabilitation Project proposed by South Yuba River Citizens League.

The mouth of Deer Creek was once an exceptionally rich salmon and steelhead habitat for the Yuba River. Salmon and steelhead were present on Deer Creek and Squirrel Creek, a tributary of Deer Creek, in large numbers in the early part of the 20th century. Steelhead were observed in the 1960's in the first quarter mile of Deer Creek, until the impassible falls, and salmon were observed in large numbers in the 1920's (Yoshiyama, Gerstung, Fisher, and Moyle).

Lake Wildwood reservoir dam on Deer Creek, constructed in 1970, blocks the downstream movement of gravel that is essential for fish spawning habitat, and causes severe impacts to all elements of Deer Creek's riverine function, especially temperature, flow, and nutrient loads. Friends of Deer Creek has worked for the past several years with the Lake Wildwood Lake Committee to make changes to their recreational management of the reservoir that take into account the impacts to the creek. Much work remains if Deer Creek's salmon and steelhead spawning habitat is to be restored and expanded. This proposal is an effort to mitigate the impacts to the creek and make permanent changes in the management of the system that prevent the impacts from recurring.

Assessment, planning and design can begin immediately, with implementation beginning in September 2009. All necessary permits for the implementation of this project have been submitted.

The project elements are as follows:

1. Gravel Augmentation: Lake Wildwood dam is located four and a quarter miles above the confluence with the Yuba, where it has a detrimental impact on Deer Creek's remaining salmon and steelhead spawning habitat. The primary objective of this project is to work with Lake Wildwood to recover the gravel that is prevented by the dam from passing downstream, and to place it along with purchased gravel as needed in the gravel-starved lower reaches of Deer Creek that are critical spawning habitat. While mercury-laden fines are able to cross the dam during storm and dewatering events, larger gravel and pebbles are prevented from passing. Replacement of gravel below the dam will restore a critical ingredient of salmonid spawning habitat as well as a vital but poorly understood element in the overall function of the stream, with beneficial impacts to temperature, flow, oxygenation, and fish and other wildlife populations.

2. Revegetation: We propose a revegetation effort for the four and a quarter mile stretch of creek from the Lake Wildwood dam to the confluence. The effort will focus on the riparian zone, meadow/floodplain areas and upland zones. Like most of the watershed, this area is infested with invasive non-native species that outcompete beneficial native species and interact with the climatic conditions to create parched, tinder-dry conditions in the long hot summers. Of particular concern are Himalayan Blackberry (Rubus discolor), Black Locust trees (Robinia pseudoacacia) and non-native grasses in the riparian zone, Scotch Broom (Cytisus scoparius) and Yellow Star Thistle (Centaurea solstitialis) in the meadow areas, and Ripgut grass in the upland areas. Revegetation from the native palette would restore the capacity to uptake nutrients, thereby reducing the extent of algae blooms that have severely impacted lower Deer Creek. Algae blooms cause large diurnal swings in pH, creating conditions that are lethal to native aquatic organisms. These algae blooms and resulting pH increases have caused the State Board to include Deer Creek as an impaired watershed for pH on the 303(d) list. Revegetation will increase tree cover in the riparian zone, thereby reducing direct solar radiation available as energy for algae. Invasive Himalayan blackberry, prevalent throughout the riparian zone, provides little shade and blocks access to the creek for larger animal species. Blackberry also contributes to erosion as the stream flows around the rootball, undermining the soil. By contrast, native willows overhang the water, remain lush and green all summer long, hold the soil in their roots, and provide copious shade that keeps the water cool. Their roots provide habitat and protection from predators for a variety of animal species. Revegetation of denuded sections of the riparian zone will also help control sediment loads in the creek that result from erosion. This stretch of creek is dominated by a single highly pollution-tolerant macroinvertebrate family, indicating overall ecological degradation. Improved riparian habitat is likely to result in increased macroinvertebrate diversity in addition to providing numerous habitat and water quality benefits for the target species and other riverine and riparian dependent species.

3. Barrier Removal: The third project element is the assessment and removal of barriers to anadromous fish passage. Salmon and steelhead were once present for several miles along Deer Creek and its tributaries, but their range is now limited to the first quarter mile of stream. At this point, a large and impassible waterfall, known as Basher

## II. Project Description

Falls, prevents their passage. Salmon were once able to ascend these falls because the presence of gravels in the creek maintained the height of the stream bed and prevented the creek from incising, and large woody debris acted as natural fish ladders to facilitate fish passage. Gravel loads upstream of the falls will restore stream elevation, and targeted gravel placement at the falls will focus on restoring passibility. Native trees, once established, will provide the necessary large woody debris. In addition, we will explore and implement other options for restoring passibility to the falls as indicated. We will also survey any additional barriers to fish passage that lie between the confluence and Lake Wildwood, in an effort to expand habitat range to the entire 4.25 mile stretch of creek, and up to 2.5 additional miles of Squirrel Creek, a tributary of Deer Creek below Lake Wildwood.

4. Collaborative Management of Lake Wildwood and Wastewater Treatment Plant: Lower Deer Creek's potential salmon and steelhead spawning habitat is gravely compromised by the presence of Lake Wildwood dam and wastewater treatment plant, with water temperatures in the fall that are lethal to fish, severe lack of suitable gravels, and an extreme excess of nutrients that contribute to rampant algae blooms. Restoration of viable habitat in this creek, the last tributary spawning grounds for the Yuba River before fish passage is blocked by Englebright Dam, depends on Lake Wildwood's and the Wastewater Treatment Plant's adoption of management practices that reduce impacts to the downstream ecosystem. Necessary changes include increasing the summer flow in order to reduce downstream temperature; releasing from cooler deep waters; collecting gravel during dredge operations for downstream placement; reducing the high flows during the periodic release by further lengthening the duration of the release; and reducing the input of nutrients from the Wastewater treatment plant. Central Valley Regional Water Quality Control Board is in the process of imposing stricter limits on nitrates and phosphates in effluent in order to meet their regional targets. Lake Wildwood has chosen Friends of Deer Creek to implement salmon habitat restoration improvements as a mitigation for their excessive nutrient loads, and that project will complement the current proposal. New technology exists that will result in reduced nutrient loads when implemented. Friends of Deer Creek has established a good working relationship with the Lake Wildwood Lake Committee over the course of several years, in the interest of preserving our shared environment. The fruits of this collaboration are already evident in changes that the Lake Committee has implemented in lengthening the duration of the periodic release, thereby reducing the high flows; posting signs that warn anglers of the dangers of mercury in fish; developing a joint water quality monitoring program at four sites in and below the reservoir; creating an inspection station for boats to prevent the spread of invasive non native species including quagga mussels; and collaborating in a study of mercury-laden sediment that is transported over the dam during storms. Friends of Deer Creek's board of directors includes John Norton, a Lake Wildwood resident, member of the Lake Committee, and retired program director at the California State Water Resources Control Board, who has been instrumental in establishing a partnership.

## III. Species Limiting Factors

**In this section, describe the limiting factors for spring-run Chinook salmon and steelhead in your watershed. The last page of this questionnaire defines the limiting factors.**

| Limiting Factors | Description (from back page) | Rank |
|---|---|---|
| ☒ **Channel Form** | Lake Wildwood Dam's construction in 1970 has resulted in drastic changes to the channel form below the dam in the critical salmon spawning reach. While the presence of the dam has not essentially changed the peak flow, the dam prevents the passage of gravels that modulate flow. The fact that there is flow capable of transporting and depositing gravel without a supply of gravel has resulted in the creek incising into its bedrock and alluvium below Lake Wildwood to the confluence. The availability of flow but not of gravel and cobbles has also had the effect of incising the creek at the falls and steepening the gradient, transforming the falls into an impassible obstacle and limiting salmon and steelhead habitat range to the quarter mile stretch between the falls and the confluence. A further | Critical |

| | | |
|---|---|---|
| | consequence of the combination of high flow and gravel starvation is bed armoring, particularly in reaches from Lake Wildwood to Squirrel Creek. Bed armoring is a particular problem in alluvial reaches, resulting in a reduction in habitat diversity. Finally, there is a large amount of angular sediment below the dam due to local erosion caused by construction at Lake Wildwood. Source data: Friends of Deer Creek Geomorphic Assessment, based on protocols developed by Montgomery and Buffington 1997. | |
| ☒ **Channel Unit Types** | The lack of sediment has contributed to a reduction in riffle frequency caused by changes to the substrate. The stretch of creek below Lake Wildwood to the confluence with Squirrel Creek is particularly impacted by infrequency of riffles. The reduction in riffle habitat has the potential to raise temperatures, lower dissolved oxygen concentrations, and reduce habitat suitability. The lack of sediment also causes the creek to incise into alluvial step pools, reducing turbulent flows and dissolved oxygen concentrations. The reduction in gravel has also led to the deepening of pools, making them less suitable for spawning because of the loss of oxygenated flow. Deep pools can reduce the hyporheic flows needed to buffer daily temperature swings. Deep pools also reduce dissolved oxygen concentrations and contribute to algae blooms. Finally, the dam blocks large woody debris which can provide side channel pool habitat and help with gravel retention, thereby creating riffles and increasing the suitability of pools for spawning. The lack of woody debris decreases the diversity of channel units. Source data: Friends of Deer Creek Geomorphic Assessment, based on protocols developed by Montgomery and Buffington 1997. | High |
| ☒ **Substrate** | Lake Wildwood dam blocks gravel and cobbles which would provide habitat to lower Deer Creek. The reach between Lake Wildwood and Squirrel Creek is particularly impacted, with only localized sediment inputs. The composition of the streambed below Lake Wildwood has been fundamentally altered since the construction of the dam because the reduction of the sediment supply has led to bed armoring, and a large median substrate diameter unsuitable for spawning salmonids. Fine sediment however is able to pass downstream, leading to a disproportionate amount of fine substrate too small for spawning habitat. Localized gravel recruitment leads to uneroded, angular gravels. The entire system is starved of suitable gravel supply because of the presence of the dam. Source data: Wolman Pebble Counts done in conjunction with Geomorphic Assessment. | Critical |
| ☒ **Structure** | The presence of two dams (Lake Wildwood and Scotts Flat) has interrupted the continuous system that would bring large woody debris from upland forests. The lack of woody debris affects the distribution and spacing of riffles, runs, and pools. Debris creates unique and diverse habitat types including side channel pools, lateral pools, mid channel pools, and riffles.Source data: Friends of Deer Creek Geomorphic Assessment, based on protocols developed by Montgomery and Buffington 1997; Physical Habitat Assessments conducted in 2007 and 2008 in accordance with SWAMP Stream Habitat Characterization Form; Desktop analysis | High |

| | | |
|---|---|---|
| | using Google Earth to assess canopy cover. | |
| ☒ **Flow** | Lake Wildwood has a severe impact on flow, with inadequate flow in the summer months and unseasonal high flows during the annual dewatering. The dewatering event mimics a storm event, triggering salmon and steelhead to begin their upstream journey to spawn, where the eggs then dry up when the waters recede. The high flows also scour the vegetation and macroinvertbrates from the downstream section of the creek, causing severe impacts to riparian vegetation and habitat. The area is dominated by a single macroinvertebrate family, blackflies (Simulidae), and suffers from a critical lack of the macroinvertebrate diversity needed by salmonids. The entire Deer Creek watershed functions as a water management system. The natural flow regime would allow snowmelt to pass all the way into lower Deer Creek. Snow melt is now blocked and diverted at numerous places. Winter high flows are similar to historic highs, but data collected since 1934 reveals a significant reduction in summer flows resulting from Lake Wildwood's flow management (USGS). Below Lake Wildwood, less flow results in more pronounced diurnal temperature swing, and more severe environmental stresses on organisms. Source data: Flow regime analysis using USGS gauge data and Army Corps of Engineers Hydrologic Engineering Center Statistical Software Package. | Critical |
| ☒ **Temperature** | Temperature is an urgent limiting factor in Lower Deer Creek. Temperature increases caused by human actions are a severe problem in lower Deer Creek. Temperatures of 24 degs C are lethal to salmonids, with 23 degs C being the LT50 (Baker). Ten years of temperature data on Deer Creek in the salmonid spawning reach reveal lethally high temperatures in the summer and fall spawning season, with peaks of 30 degs C (Friends of Deer Creek). Management activities on private land such as grazing, logging, gravel mining, and agriculture have led to degradation of the riparian corridor, reduction in riparian habitat and invasion by non-native plant species that bring reduced shade and habitat benefits. The lack of gravel and cobble in the streambed has led to a deepening of pools and a reduction in turbulent riffle flow and riffle spacing, all of which factors can lead to temperature increases (Grant et al, 2006). Managed flow from Lake Wildwood has significant impacts on downstream temperature caused by several factors: summer release of warm water from surface waters of the reservoir; extremely low outflows in summer in order to conserve reservoir depth; and a lack of natural variation in both flow and temperature, reducing the potential for hyporheic exchange to act as a temperature buffer (Poole & Berman). Source data: Friends of Deer Creek monthly water quality data; Onset HOBO data logger data during Lake Wildwood dewatering. | Critical |
| ☒ **Water Quality** | The primary impacts to the water quality are nutrient loads, algae, and large diurnal swings in pH and temperatures.The wastewater treatment plant at Lake Wildwood releases significant quantities of nutrients into lower Deer Creek, which have contributed to excessive algae blooms. Algae take in oxygen and release carbon | Critical |

| | | |
|---|---|---|
| | dioxide, leading to large diurnal swings in pH and dissolved oxygen, with severe impacts on stream organisms. Deer Creek below Lake Wildwood is 303(d) listed for pH as a result of excessive nutrient loads (http://www.waterboards.ca.gov). The impact of nutrient-laden effluent from the wastewater treatment plant is especially pronounced in summer when the low flows prevent effluent dilution. The lack of riparian canopy also increases the availability of solar radiation to the streambed, contributing to algae blooms. Denuded riparian areas do not uptake nutrients, leaving the nutrients available for algae growth. Source data: Friends of Deer Creek monthly monitoring data. | |
| ☒ **Passage** | Fish passage is completely blocked by a waterfall located a quarter mile above the confluence with the Yuba River. Salmon and steelhead were historically able to scale these falls, but the lack of gravel, cobbles and large woody debris to act as natural fish ladders, has caused the creek to become deeply incised and the falls to become too steep to pass. Source data: Visual and Geomorphic Assessment based on protocols developed by Montgomery and Buffington 1997. | Critical |
| ☒ **Riparian/Floodplain** | The riparian vegetation is significantly compromised both by the spread of invasive non-natives, and by private land management including grazing, logging, mining, and residential development, that has caused the banks to become denuded in places. Aerial photography reveals severely degraded vegetation in more than half of Deer Creek's riparian zone between Lake Wildwood and the Yuba confluence, and even more of Squirrel Creek's riparian zone in 3.2 miles above the confluence with Deer Creek.These impacts result in temperature increases, a reduction in nutrient uptake capacity, and the loss of fish and macroinvertebrate habitat. Riparian vegetation has been found by many studies to be critical in regulating stream temperature (Johnson & Jones, 2000). Riparian areas with higher plant density and basal area have temperatures up to 11% lower than areas with significantly lower plant density and basal area (Opperman & Merenlender, 2004). Non natives such as blackberry outcompete native species such as willow, alder, and cottonwood that provide suitable habitat including canopy, shading, root mats and root wads. The composition of the riparian vegetation zone is crucial to stream temperature regulation, and must include tree species that provide canopy (Broadmeadow & Nisbet, 2004). The riparian zone at the site is currently dominated primarily by shrub-like Himalayan blackberry and Scotch broom, which do not provide the necessary canopy cover to effectively regulate the stream temperature. Non natives such as scotch broom are more susceptible to wildfire, which in turn increases fine sediment load to the creek. Grazing animals cause further impact to native vegetation by spreading non-native seeds and by trampling and compacting soil, making it less hospitable to native species that require specific soil characteristics in order to be successful. The lack of large native riparian trees reduces the availability of large woody debris in the creek necessary for habitat and for fish passage. The lack of gravel has caused the creek to become incised, particularly in the alluvial reaches, and unable to access its | Critical |

## III. Species Limiting Factors

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| | floodplain. Source data:Physical Habitat Assessments conducted in 2007 and 2008 per SWAMP Stream Habitat Characterization Form; Habitat Assessment conducted in conjunction with Friends of Deer Creek twice yearly Macroinvertebrate Bioassessment since 2000; streamwalk visual assessment, May 2008. |

**Source Documents:**


Baker, P.F., Speed, T.P., and F.K. Ligon. 1995. Estimating the influence of temperature on the survival of chinook salmon smolts (Oncorhynchus tshawytscha) migrating through the Sacramento - San Joaquin River Delta of California. Can. J. Fish. Aquatic. Sci 52:855-863.

Broadmeadow, S. & Nisbet, T.R. 2004. The effects of riparian forest management on the freshwater environment: a literature review of best management practice. Hydrology and Earth System Sciences 8(3), 286–305.

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Opperman, J.J. & Merenlender, A.M. 2004. The effectiveness of riparian restoration for improving instream fish habitat in four hardwood-dominated California streams. North American Journal of Fisheries Management 24, 822–834.

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Yoshiyama, R. M., E. R. Gerstung, F. W. Fisher, and P. B. Moyle. 2001. Historical and present distribution of chinook salmon in the Central Valley. Pages 71-176 in R. Brown, ed. Contributions to the biology of Central Valley salmonids. Fish Bulletin 179. http://wfcb.ucdavis.edu/www/Faculty/Peter/petermoyle/publications/CentralValleyChinook.pdf


**Additional Notes:**

## IV. Project Objectives—Environmental

**In this section, describe how your project will affect one or more of the limiting factors for spring-run Chinook salmon or steelhead described above.**

| Limiting Factor | Description and Objective | Focus |
|---|---|---|
| ☒ **Channel Form** | The gravel augmentation effort will affect the channel form by reducing the rate of channel incision into the streambed and bedrock. The armoring of the streambed that prevails in the reach between Lake Wildwood and Squirrel Creek will be mitigated by providing a | Primary |

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| | more natural and diverse substrate regime, balancing out the large boulders and bedrock with smaller gravel, and reducing the incision rate. The project objective is to reduce the median substrate diameter by 25%. | |
| ☒ **Channel Unit Types** | The project will place gravel in the sediment-starved reach of Deer Creek below Lake Wildwood, creating riffles and side pools that are necessary to decrease temperature and increase dissolved oxygen. Replacement of gravel will also prevent the creek from incising and developing deep stagnant pools. The revegetation project will provide sources of large woody debris that help to create diverse channel unit types. The project objective is to increase riffle habitat by 30%. | Primary |
| ☒ **Substrate** | The addition of gravel recovered from Lake Wildwood and from Yuba River sources will reduce the median substrate diameter to a diameter more suitable for salmon spawning. Diverse substrate will reduce incision and create more spawning bed habitat. The presence of large quantities of angular sediment from local sources will be mitigated by a combination of removal of angular gravel where practical and increased abundance of rounded pebbles more suitable for spawning habitat. Finally, the addition of diverse substrate will create more hyporheic flow by creating riffles and raising the bed elevation, resulting in reduced temperature and increased dissolved oxygen levels. The project objective is to reduce median substrate diameter by 25%. | Primary |
| ☒ **Structure** | The proposed revegetation effort in the riparian zone below Lake Wildwood and along Squirrel Creek will replace low-lying invasive shrubs with native trees, resulting in local sources of large woody debris. Woody debris facilitates the creation of riffles and pools, and acts as a natural fish ladder. The project objective is to increase woody debris biomass by 100%. | Primary |
| ☒ **Flow** | The gravel augmentation will affect the flow regime by raising the bed elevation, decreasing surface flow and increasing subsurface hyporheic flow. The revegetation will affect flow by providing a source of large woody debris which will create diverse channel unit types and an increase in riffles and sidepools. We will negotiate with Lake Wildwood and Nevada Irrigation District (NID) to make changes to their future management strategies that may include releasing colder water, reducing flow during the periodic dewatering by lengthening the timeframe, and ensuring that the summer release meets the minimum flow levels required under the terms of their permit. The project objective is to ensure that Lake Wildwood's spring, summer and fall flows meet their permitted requirements 100% of the time. | Primary |
| ☒ **Temperature** | The project will realize significant improvements to temperature. We plan to import gravel recovered from Lake Wildwood and from the Yuba River, to create riffles that have the capacity to reduce temperature and increase dissolved oxygen. We will work with Lake Wildwood to manage the summer release of water from a lower depth, so that colder water is entering the stream. We will work with landowners to fence grazing animals out of the riparian zone so that | Primary |

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| | native vegetation can become established, and will focus revegetation efforts on increasing the supply of native shade trees. The project objective is to reduce instances of lethal temperature peaks to zero. | |
| ☒ **Water Quality** | Water quality impacts are interconnected, with the lack of riparian vegetation and canopy contributing to high temperatures and the growth of excessive algae blooms, which in turn leads to large diurnal swings in pH and temperature. The proposed revegetation will increase canopy and overall biomass, thereby increasing the capacity to uptake the nutrients that feed algae blooms and reducing temperature and solar radiation, further reducing algae blooms. The reduction of algae blooms in turn will reduce pH and dissolved oxygen concentration swings. The gravel augmentation will raise bed elevation and create riffle habitat, with increased turbulence that increases dissolved oxygen concentrations. The gravel will also increase subsurface flow to provide a buffer against temperature spikes. We will reduce algal biomass by 25%, and nutrients by 25%. | Primary |
| ☒ **Passage** | The project will include an effort to restore passibility to the falls a quarter mile from the Yuba confluence in order to regain four miles of salmon habitat on Deer Creek and up to 2.5 miles on Squirrel Creek. It is hypothesized that the falls have become excessively steep for a combination of human-caused reasons, including the lack of gravel that causes the creek to incise, and the geomorphological changes to the creek that were caused by intensive gold mining in the creek beginning in the Gold Rush. We plan to restore passibility by a combination of gravel augmentation to raise the streambed height and fall height reduction, by removing accumulated debris at the top of the falls. The project objective is to increase habitat range by 4 miles on Deer Creek and 2.5 miles on Squirrel Creek. | Primary |
| ☒ **Riparian/Floodplain** | The project includes an extensive revegetation effort along 4.25 miles of Deer Creek and an additional 3.2 miles of Squirrel Creek. The denuded areas will be replanted with native trees; invasive non-natives will be removed and replaced with native vegetation; and grazing animals that compact the soil and eat the seedlings will be fenced away from the riparian zone. The gravel augmentation effort will prevent the creek from incising and will allow it to access its floodplain. Friends of Deer Creek's wide volunteer network and relationships with private landowners make us uniquely positioned to implement revegetation efforts on private land and to work with landowners to make beneficial changes to private land management practices. We will reduce the total denuded area of the riparian zone from 33% to 15%. | Primary |

## V. Project Objectives—Biological

**In this section, describe the objective(s) of your project relative to the goal of providing habitat for spring-run Chinook salmon and steelhead. Indicate the species and life stage that are targeted by the project. (It is okay to have more than one species/life stage target).**

**Target Species:** ☒ Spring-Run Chinook Salmon **Population Status Specific to Watershed:** Intermittent

**Target Life Stages:**

☒ Spawning ☒ Egg Incubation ☒ Summer Rearing ☒ Winter Rearing

☐ Juvenile Emigration ☒ Adult Immigration ☐ Adult Holding

**Description of Project Objectives:**

The objective of the project is to increase the proportion of Yuba River salmon found on Deer Creek by 5-10%. The habitat requirements for spring-run Chinook salmon will be addressed in the following manner by the proposed project:

Adult Immigration: High temperatures deter adult salmon from entering their natal streams, and are a problem in Deer Creek for the reasons stated in III above. Our monthly monitoring data, available on our website, indicates that the temperature range in the creek is just above the upper limit of tolerable temperature range. High temperature peaks and extreme temperature swings will be addressed by revegetating to increase shade; by adding gravel to increase riffle habitat and hyporheic flows; and by working with Lake Wildwood management to release water in summer from lower and colder depths of the reservoir. Migrating salmon avoid streams with excessive turbidity. Deer Creek's turbidity is not excessive, but the revegetation project will address sediment loads by vegetating denuded banks to reduce erosion. We will also work with landowners to fence grazing animals away from the riparian zone, where they contribute to erosion by compacting the soil and eating seedlings. In order to expand the available habitat on Deer Creek beyond the current 1/4 mile, it is necessary to address the impassibility of Basher Falls and determine whether it can be made passible. A survey of the falls will examine pool depth to falls height ratio, vertical and horizontal distance, and whether an alternate route under the falls can be developed to facilitate fish passage.

Spawning: The most significant variables affecting spawning habitat are substrate composition, cover, water quality and water quantity. In terms of water quantity, flow is impacted in Deer Creek by Lake Wildwood dam, with low summer flows and unnaturally high flows during the periodic dewatering. Suitable salmon spawning habitat requires sufficient but not excessive flow, and our work with Lake Wildwood will focus on ensuring that minimum summer flows are observed and that the duration of the dewatering is extended to allow a lower flow rate. Temperature provides an important cue for spawning salmon, with the ideal temperature range being 5.6-13.9 deg C. Timing of spawning must take into account the seasonal temperatures that affect subsequent incubation success rates - successful spawning requires suitable temperatures at just the right time. As outlined above in Adult Immigration, temperature impacts will be addressed by a combination of revegetation efforts, reservoir management strategies, and gravel augmentation. Of critical importance to spawning habitat is suitably-sized substrate, with salmon requiring gravel in the range of 1.3 to 10.2 cm. Up to 80% of the gravel should be in the range of 1.3 to 3.8 cm, with the remainder up to 10.2cm. As outlined above, the targeted stretch of creek is gravel-starved as a result of the dam at Lake Wildwood that prevents the passage of gravel downstream. The gravel augmentation effort in this project will recover gravel from the reservoir and augment with purchased gravel from a Yuba River source in order to increase the ratio of suitable substrate. Finally, spawning salmon require adequate cover for shade and for protection from predators. Cover may be provided by overhanging vegetation, undercut banks, submerged vegetation, submerged objects such as logs and rocks, floating debris, deep water, turbulence, and turbidity. The project will include an extensive revegetation of the riparian zone focused on increasing native shade cover and providing a supply of large woody debris.

Incubation: While spawning habitat is also incubation habitat, the needs of embryos during incubation differ from those of adults. Of particular importance is the quantity of fine sediment that can block oxygenated flow in the redds and restrict alevin movement. The revegetation will reduce fine sediment loads by restoring erosion-prone denuded

## V. Project Objectives—Biological

areas. Dissolved oxygen concentrations also have an impact on incubating salmon, with low and medium DO levels corresponding to smaller, weaker and fewer alevins. DO concentrations are impacted by temperature, surface and intragravel water interchange, substrate permeability, and oxygen demand of organic material in the redd. The project will result in increases in dissolved oxygen levels by reducing water temperature through a combination of revegetation, gravel augmentation, and changes to reservoir management; reducing algae blooms by increasing riparian vegetation that will uptake nutrients and provide shade; increasing the proportion of gravels to fine sediment; and increasing riffle habitat and thereby increasing hyporheic flow. Incubation success is influenced strongly by temperature, with temperatures in the higher end of the ideal range greatly reducing the number of days until embryos hatch. Proposed temperature mitigations are as described under "Adult Immigration", above.

Rearing: Abundance of juvenile salmon is impacted by a range of variables including vegetative cover, protection from predators, abundance of food sources, flow, water quality including DO concentrations and pH, temperature, competition, depth, velocity, and substrate. Project impacts to temperature, water quality, flow, substrate, and vegetative cover/protection from predators have been discussed in the above sections. The project will have a significant impact on macroinvertebrate habitat, with habitat improvements resulting from the revegetation and substrate improvements. Macroinvertebrates constitute the major food source for salmonids. Both suitably-sized substrate and large native trees and their woody debris are crucial in increasing macrinvertebrate populations and in providing protective cover to juvenile salmon.

**Target Species:** ☒ Steelhead

**Population Status Specific to Watershed:** Extirpated

**Target Life Stages:**

☒ Spawning ☒ Egg Incubation ☒ Summer Rearing ☒ Winter Rearing

☐ Juvenile Emigration ☒ Adult Immigration

**Description of Project Objectives:**

The project objective is to return steelhead to Deer Creek. While steelhead were historically present in the watershed, it is thought they are no longer found here. The project impacts for spring-run chinook habitat will yield comparable benefits for steelhead. The temperature range for spawning steelhead is 3.9-9.4 deg C. There is considerable overlap in the ideal range for all habitat variables for salmon and steelhead, and the project will yield benefits that will accrue to both species. While steelhead are not currently present in Deer Creek because of habitat degradation, they are still present in the Yuba River in the vicinity of Deer Creek, and it is hoped that the project will restore Deer Creek's habitat to viability.

## VI. Project Cost

**Capital Cost:** $75,000 for equipment

**Annual Operation and Maintenance Cost:** $174,000 annual operation costs for the project term of 3.25 years

$275,000 annual maintenance costs

**Annual Operation and Maintenance Description:** For the 3.25 year term of the project, the project will salvage gravel from Lake Wildwood and purchase additional Yuba River gravel as needed; deposit the gravel below Lake Wildwood dam and at the falls annually; remove non-native riparian vegetation; revegetate with native vegetation; irrigate as needed; monitor and remove non-native vegetation; conduct meetings with Lake Wildwood Lake Committee to implement management changes; survey barriers to fish passage and remediate; implement monitoring program.

## VI. Project Cost

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| **Project Lifespan:** | Funding is requested for the 3.25 year project term. Operating and maintenance activities are expected to be required indefinitely, as long as the dam at Lake Wildwood is present. Immediate benefits are expected in macroinvertebrate populations, as soon as suitable gravel is restored, with salmon and steelhead numbers showing an improvement within three years. Long term benefits in riparian vegetation will continue to accrue for the next ten years. |
| **Project Partners (Funding):** | Nevada County Sanitation District #1, a compensatory mitigation imposed by California Department of Fish and Game. |
| **Project Partners (Maintenance):** | Lake Wildwood Association will be maintenance project partners, providing salvaged gravel and other remedial actions in their management plan as developed in the scope of the project. |

## VII. Schedule

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|---|---|
| **Proposed Start:** | September 2009 |
| **Expected Time to Completion:** | December 2012 |
| **Expected Time to Realize Environmental Benefits:** | 2019 |
| **Expected Time to Realize Biological Benefits:** | December 2012 |

## VIII. Feasibility

**Technical Feasibility:**

The technical elements of the project include gravel augmentation, riparian revegetation, and barrier removal.

The gravel augmentation element is feasible because we have convenient access for depositing gravel loads at Lake Wildwood dam, as well as a cooperative relationship with Lake Wildwood Lake Association who have granted us permission to access their land for this purpose. Lake Wildwood Association has been seeking solutions to the issue of gravel starvation in the lower reach, and is strongly supportive of efforts to recover gravel from the lake and place it below the dam. If the recovered gravel proves to be unsuitable or insufficient, we have identified an alternative source of gravel from the Yuba River, which can be trucked in to the site.

The riparian revegetation effort is feasible because of our strong relationships developed over many years with landowners along the creek, some of whom are volunteers and monitors for our organization. We have secured formal consent to implement revegetation efforts from landowners of approximately one third of the land area along Deer Creek between Lake Wildwood and the Yuba confluence, and will continue working to secure additional permissions. Friends of Deer Creek has already completed a similar revegetation effort that involves the removal of non-natives and replacement with native trees and plants in an upstream reach, and has developed a method of incremental removal of

## VIII. Feasibility

invasives to avoid exacerbating the erosion problem; revegetation in targeted sections that can outcompete the invasive vegetation; and gathering of native seedlings and cuttings from a variety of specimens in the project area in order to ensure genetic diversity and suitability.

Barrier removal will consist primarily of a feasibility study to determine the best method of bypassing Basher Falls and implementation as appropriate. The effort to restore passibility by targeting gravel placement to elevate streambed height is made possible by good access at the falls, that will allow us to focus a specific "gardening"-style gravel placement at the site. The introduction of large numbers of native trees will restore the supply of large woody debris that in the past acted as a natural fishladder to facilitate fish passage.

**Technical Challenges:**

Technical challenges remain in the restoration of passibility to the falls. Anecdotal evidence suggests that historically, salmon and steelhead were able to scale these falls and were found in the upper reaches of Deer Creek, but the falls are known to have been impassible since at least the 1920's, before the construction of Lake Wildwood dam. An initial study of the falls has shown that there is an access point at the bottom of the falls approximately 10" in diameter, and that it is possible that fish passage could be occur via this route instead of up the face of the falls. If fish passage cannot be restored, the habitat range will be limited to the first quarter mile of stream above the Yuba confluence, but riparian revegetation and gravel augmentation efforts would be implemented in the entire 4.25 mile stretch of the creek between Lake Wildwood and the confluence in order to realize greater temperature and pH improvements.

The temperature peaks in the creek currently are lethal to spawning fish, and a primary goal of all elements of the project is to reduce temperature peaks and swings. The related projects below reveal that improvements in temperature suitability result from each planned remediation strategy, and taken together we believe that the project in its entirety will restore habitability.

**Related Projects:**

All elements of the project have been successfully implemented in other waterways:

Barrier Removal: In Puget Sound, when access to 145 rkm in the upper Skykomish River above Sunset Falls (a natural barrier) was provided, chinook and pink salmon penetrated the upper reaches of the basin, and their populations peaked in 15 and 25 years, respectively (Seiler 1991).

Nutrient Uptake: The plan to plant native plants in denuded areas and as a replacement for non-native shrubs has been shown to result in a significant reduction in nutrient loads in the creek, with willows being extremely efficient at nutrient uptake (Byrd & Kelly 2006).

Native Revegetion Benefits: A revegetation project in Mendocino County targeted at steelhead habitat restoration yielded significant temperature benefits, beneficial changes in channel morphology, and a supply of large woody debris within 10-20 years that was equal to that found on similar streams in mature forest (Opperman & Merenlender 2004).

Gravel Augmentation: East Bay Municipal Utility District has implemented a series of gravel augmentation activities over several years in the Mokelumne River just below Comanche Dam. The augmentation has yielded multiple

## VIII. Feasibility

benefits, including the immediate return of spawning Chinook salmon to two sites; a 12% increase in the quantity of suitably-sized gravels; increased dissolved oxygen and decreased temperatures; and macroinvertebrate populations in the new gravel that are equal to those found in established gravel (Bjornn & Reiser, Mokelumne).

**Ownership or Permitting Challenges:**

We are fortunate to have developed harmonious relationships with several landowners along the creek and with Lake Wildwood. Therefore, it is not anticipated that land ownership issues will be a significant obstacle.

We have applied for the following permits for this project:

Army Corps of Engineers, Section 404 Permit

Department of Fish and Game, Lake and Streambed Alteration Permit

Central Valley Regional Water Quality Control Board, Water Quality Certification Section 401 Permit

**Conflicts with Cultural, Zoning, or Other Issues:**

There are no known conflicts with cultural, zoning, or other issues. On the contrary, our close collaboration with the Tsi-Akim Maidu has revealed to us that the return of the salmon people to their ancestral lands is their highest priority, as indicated by their revival of the "Calling Back the Salmon" ceremony for the past few years in the fall. Efforts to restore salmon habitat are of paramount cultural importance.

## IX. Project Support

**Supporting Entities:**

The Tsi-Akim Maidu Tribe is supportive of the goals of this project.

Support for elements of this project is implicit in the fact that in August 2008 the California Department of Fish and Game included Deer Creek on its list of 22 priority streams for future instream work. The list was compiled and ranked based on input from Regional DFG staff, staff from the State Water Board, U.S. Fish and Wildlife Service, and the National Marine Fisheries Service, using the following criteria: 1) Presence of anadromous species; 2) likelihood that DFG flow recommendations would provide a high level of improvement; 3) availability of recent flow studies or other relevant data; and 4) the possibility of partners/willing landowners. T

**Cooperating Entities:**

Lake Wildwood, Nevada County Sanitation District #1, and private property owners along the affected stretch of creek have all offered their formal cooperation, and support letters are available.

**Degree of Local Support:**

Friends of Deer Creek enjoys a high degree of local support and places a priority on building cooperative relationships with all affected parties, private and public. Several homeowners along the creek have become volunteers and monitors; the city of Nevada City is currently partnering with us on an EPA-funded Brownfield Assessment of abandoned mines on city-owned land, and has provided us with low-rent office and lab space for the past decade; Lake Wildwood has collaborated with us on mulitple projects and, as a result of our collaboration, has modifed its management practices of the reservoir to take into account impacts to the creek; and we are developing an eight mile community trail along the creek, in partnership with several local groups, which promises to

## IX. Project Support

be a highly valued local resource and which has engendered much support and volunteer hours from a broad spectrum of the community. These relationships make it possible for us to accomplish many things that would be hard for a state agency to do, especially when access to private property is required as it is in this project.

**Known Opposition:** There is no known opposition to this project.

## X. Supporting Documents

**Please provide a full reference for each citation used to support the information presented in this questionnaire.**


Baker, P.F., Speed, T.P., and F.K. Ligon. 1995. Estimating the influence of temperature on the survival of chinook salmon smolts (Oncorhynchus tshawytscha) migrating through the Sacramento - San Joaquin River Delta of California. Can. J. Fish. Aquatic. Sci 52:855-863.

Bjornn, T.C. and D.W. Reiser. "Mokelumne River Spawning Habitat Improvement Project Monitoring". American Fisheries Society Special Publication, 1991. http://www.delta.dfg.ca.gov/AFRP/

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Byrd, Kristin B. and Maggi Kelly. Salt Marsh Vegetation Response To Edaphic And Topographic Changes From Upland Sedimentation In A Pacific Estuary. Department of Environmental Science Policy, and Management, University of California, Berkeley. Wetlands, Vol. 26, No. 3, September 2006, pp. 813–829.

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Seiler, D. 1991. Coho production potential above Snoqualmie Falls. Open File Report, 15 January 1991. Planning, Research, and Harvest Management Division. Washington Department of Fisheries, Olympia,WA.

Yoshiyama, R. M., E. R. Gerstung, F. W. Fisher, and P. B. Moyle. 2001. Historical and present distribution of chinook salmon in the Central Valley. Pages 71-176 in R. Brown, ed. Contributions to the biology of Central Valley salmonids. Fish Bulletin 179.
http://wfcb.ucdavis.edu/www/Faculty/Peter/petermoyle/publications/CentralValleyChinook.pdf

## X. Supporting Documents

## Definitions of Limiting Factors for Spring-Run Chinook Salmon and Steelhead

### Channel Form

This attribute describes changes to the channel, including incision, aggradation, diking, armoring, and other modifications of the channel adversely affecting spring-run Chinook salmon and steelhead.

### Channel Unit Types

Examples of geomorphic features of the channel that form habitat types for spring-run Chinook salmon and steelhead are pools, riffles, glides, and runs. This attribute describes changes in the frequency and size of such features. For example, removal of large wood may reduce the frequency of pools, presence of steps, or retention of gravel for riffles.

### Substrate

This attribute describes changes in the composition of the substrate of the stream, including increase in fine sediment and lack of gravel recruitment.

### Structure

This attribute describes the loss of structural elements in the stream such as large wood, boulders, undercut banks, and so on. Loss of structure results in a simplification of the channel and influences Channel Form and Channel Unit Types.

### Flow

This attribute addresses modification of the flow regime, including decrease in summer low flow, increased "flashiness," and dewatering of the channel as a result of withdrawals.

### Temperature

Change in water temperature can be attributable to human actions such as removal of riparian shading. This attribute describes the increase in summer water temperature and the loss of temperature refugia (springs or groundwater) as a result of human actions.

### Water Quality

This attribute pertains to the input to the stream of toxins or pollutants that produce adverse impacts on spring-run Chinook salmon or steelhead. This can include chemical pollutants such as fertilizer and pesticides and nutrient sources such as cattle and feedlots.

### Passage

This relates to the effect of impediments to adult or juvenile migration of spring-run Chinook salmon or steelhead, including dams, culverts, channel dewatering, and other structural and channel modifications. Please describe the location of the passage impediment and describe the extent of impediment (i.e., a complete or partial blockage to migration).

### Riparian/Floodplain

This attribute describes the loss of functionality of the riparian forest/vegetation and the connection of the stream to the floodplain during high water and flooding.

## Population Condition Definitions for Section V. Project Objectives—Biological

### Increasing

Adult returns of the target species to the watershed have generally been increasing over the last several years; expectations are that the species is displaying characteristics of a rebuilding or healthy population.

### Stable

Adult returns of the target species to the watershed show no clear trend over the last several years.

### Decreasing

Adult returns of the target species to the watershed are declining over the last several years; the decline in abundance is a cause of concern and characteristic of a potentially unhealthy population.

### Intermittent

Adult returns of the target species are occasionally seen in the watershed, but there is no viable or sustained population in the basin.

### Extirpated

The population has been eliminated from the watershed although the species was present in the past.

### Never Present

The species has never been known to occur in the watershed.

Appendix F2

# Questionnaire received on the Antelope Creek Action

# Questionnaire

for

# Information on Potential Projects to Support Spring-Run Chinook Salmon and Steelhead in the Sacramento River Basin for the Habitat Expansion Agreement

**DUE: Friday, February 27, 2009**

**Send completed questionnaires to hea@water.ca.gov**

## I. Contact Information

| | |
|---|---|
| **Name:** | Brenda Olson |
| **Organization:** | U.S. Fish and Wildlife Service |
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| **City, State, Zip Code:** | Red Bluff, CA 96080 |
| **Phone Number:** | 530-527-3043 x227 |
| **Email Address:** | Brenda_Olson@fws.gov |

## II. Project Description

| | |
|---|---|
| **Project Name:** | Antelope Creek Tehama Wildlife Area Paynes Crossing (fish passage) |
| **Reference No. or New:** | NS-5 |
| **Project Location:** | CDFG Tehama Wildlife Area, Paynes (or Middle Slab) crossing, Ishi Road. lat 40.231639, long -121.885691. Approximate elevation, 1290 ft. |

**Project Description:**

The current road crossing is made of grate metal. The stream bed on the downstream side of the structure has downcut. Large boulders have been placed in the past to break up the velocity but that also filled in pools that spring Chinook may have used to get up and over the structure during low water years. In addition, the substrate that once filled in the grate is being washed out so juveniles moving out of the system get strained through the structure. This structure is a partial barrier, in that adults can navigate above it during high flows.

This project will build a bridge to replace the current structure. This will allow natural stream function in passage of fish, bedload, and localized narrowing of the channel where it has been impacted from the crossing impounding

## II. Project Description

water/flow.

The AFRP funded environmental compliance, permitting, and engineered design in 2008. This project will be complete in 2009. Construction could begin as early as 2010. As part of the analysis, several different alternatives were looked at, however a bridge was the best option for fish, stream function, and human safety.

## III. Species Limiting Factors

**In this section, describe the limiting factors for spring-run Chinook salmon and steelhead in your watershed. The last page of this questionnaire defines the limiting factors.**

| Limiting Factors | Description (from back page) | Rank |
|---|---|---|
| ☒ **Channel Form** | Below Edwards dam, Antelope Creek divides into many different channels. The water is divided into these channels, thereby stranding juvenile salmonids, and possibly delaying migration of adults, in low water years. When Antelope Creek overflows into New Creek at the Edwards diversion dam, the water drains into another stream, Salt Creek. This multi-channel issue is identified in the 2001 Final AFRP Restoration Plan as an Evaluation needing to be completed. | Critical |
| ☐ **Channel Unit Types** | | Select Rank |
| ☐ **Substrate** | | Select Rank |
| ☐ **Structure** | | Select Rank |
| ☒ **Flow** | Flow is an issue downstream of the Edwards dam. In low water years the stream can be dry spring through fall. What additional water rights occur downstream of the Edwards dam is unknown. | Critical |
| ☒ **Temperature** | The temperature limiting factor is related to flow. Temperatures become lethal in the valley floor once the air temperature rises and flow is diverted. | High |
| ☐ **Water Quality** | | Select Rank |
| ☒ **Passage** | Adult passage is affected by the multiple channels in the lower section, the amount of flow diverted at Edwards dam, and the partial barrier in the CDFG Tehama Wildlife Area. In addition, juvenile passage is affected by the current crossing structure in the Tehama Wildlife Area, the lack of a bypass from the two diversion canals at Edwards dam, and the multiple channels below Edwards dam. | Critical |
| ☐ **Riparian/Floodplain** | | Select Rank |

**Source Documents:**

**Additional Notes:**

## IV. Project Objectives—Environmental

**In this section, describe how your project will affect one or more of the limiting factors for spring-run Chinook salmon or steelhead described above.**

| Limiting Factor | Description and Objective | Focus |
|---|---|---|
| ☒ **Channel Form** | By removing the current structure, and allowing natural bedload movement and the thalweg to establish, the channel will become narrower through the section just upstream of the structure. Currently the channel is relatively wide and slow moving during low flow. | Secondary |
| ☐ **Channel Unit Types** | | Select Focus |
| ☐ **Substrate** | | Select Focus |
| ☐ **Structure** | | Select Focus |
| ☐ **Flow** | | Select Focus |
| ☐ **Temperature** | | Select Focus |
| ☐ **Water Quality** | | Select Focus |
| ☒ **Passage** | Removing the current structure and replacing the crossing with a bridge will allow passage at all flows and natural stream function. Adults will be able to access suitable holding and spawning habitat, increasing their survival. Depending on water year, the crossing delays or prevents upstream passage of adult spring chinook, and also entrains juvenile outmigrants. The past two spring Chinook salmon surveys (2007 & 2008) have found most, if not all, below this crossing. | Primary |
| ☐ **Riparian/Floodplain** | | Select Focus |

## V. Project Objectives—Biological

**In this section, describe the objective(s) of your project relative to the goal of providing habitat for spring-run Chinook salmon and steelhead. Indicate the species and life stage that are targeted by the project. (It is okay to have more than one species/life stage target).**

**Target Species:** ☒ Spring-Run Chinook Salmon **Population Status Specific to Watershed:** Decreasing

**Target Life Stages:**

☐ Spawning ☐ Egg Incubation ☐ Summer Rearing ☐ Winter Rearing

☒ Juvenile Emigration ☒ Adult Immigration ☐ Adult Holding

**Description of Project Objectives:**

The objective is to remove the partial passage impediment and allow free passage of adult and juvenile spring Chinook salmon at all flows. This will allow the adults to access suitable holding and spawning habitat which will

## V. Project Objectives—Biological

increase their survival.

**Target Species:** ☐ Steelhead

**Population Status Specific to Watershed:** Relative to Historical

**Target Life Stages:**

☐ Spawning ☐ Egg Incubation ☐ Summer Rearing ☐ Winter Rearing

☐ Juvenile Emigration ☐ Adult Immigration

**Description of Project Objectives:**

## VI. Project Cost

| | |
|---|---|
| **Capital Cost:** | It is estimated that the total construction cost will be around $700,000. Due to the remote location, mobilization costs may be high. In addition, finding a suitable borrow pit for bridge approaches may be spendy if material needs to be hauled any distance. Currently, there is no suitable borrow pit identified. |
| **Annual Operation and Maintenance Cost:** | |
| **Annual Operation and Maintenance Description:** | |
| **Project Lifespan:** | 50+ years |
| **Project Partners (Funding):** | USFWS - AFRP has funded the environmental documentation, permitting, and engineered design - $98,000. |
| **Project Partners (Maintenance):** | CDFG |

## VII. Schedule

| | |
|---|---|
| **Proposed Start:** | 2010 |
| **Expected Time to Completion:** | 2010, one work season |
| **Expected Time to Realize Environmental Benefits:** | immediately |
| **Expected Time to Realize Biological Benefits:** | immediately |

## VIII. Feasibility

| | |
|---|---|
| **Technical Feasibility:** | Nothing has been identified to date that would preclude building a bridge. |
| **Technical Challenges:** | Remote location, depending on bridge dimensions some road work may need to occur (widening a few curves). |
| **Related Projects:** | There is a project downstream that is addressing non-existant juvenile bypasses on 2 currently screened diversions. |
| **Ownership or Permitting Challenges:** | Ownership is CDFG, fully supportive of the project. |
| **Conflicts with Cultural, Zoning, or Other Issues:** | None identified at this point. |

## IX. Project Support

| | |
|---|---|
| **Supporting Entities:** | USFWS-AFRP, CDFG, NMFS |
| **Cooperating Entities:** | CDFG, USFWS, NMFS |
| **Degree of Local Support:** | High |
| **Known Opposition:** | None |

## X. Supporting Documents

**Please provide a full reference for each citation used to support the information presented in this questionnaire.**

Environmental documents, permits, and designs should be done by late summer/early fall. Available upon request.

USFWS. 2008. Internal document of Limiting Factors developed for 10 year CVPIA Implementation Strategy.

## Definitions of Limiting Factors for Spring-Run Chinook Salmon and Steelhead

### Channel Form

This attribute describes changes to the channel, including incision, aggradation, diking, armoring, and other modifications of the channel adversely affecting spring-run Chinook salmon and steelhead.

### Channel Unit Types

Examples of geomorphic features of the channel that form habitat types for spring-run Chinook salmon and steelhead are pools, riffles, glides, and runs. This attribute describes changes in the frequency and size of such features. For example, removal of large wood may reduce the frequency of pools, presence of steps, or retention of gravel for riffles.

### Substrate

This attribute describes changes in the composition of the substrate of the stream, including increase in fine sediment and lack of gravel recruitment.

### Structure

This attribute describes the loss of structural elements in the stream such as large wood, boulders, undercut banks, and so on. Loss of structure results in a simplification of the channel and influences Channel Form and Channel Unit Types.

### Flow

This attribute addresses modification of the flow regime, including decrease in summer low flow, increased "flashiness," and dewatering of the channel as a result of withdrawals.

### Temperature

Change in water temperature can be attributable to human actions such as removal of riparian shading. This attribute describes the increase in summer water temperature and the loss of temperature refugia (springs or groundwater) as a result of human actions.

### Water Quality

This attribute pertains to the input to the stream of toxins or pollutants that produce adverse impacts on spring-run Chinook salmon or steelhead. This can include chemical pollutants such as fertilizer and pesticides and nutrient sources such as cattle and feedlots.

### Passage

This relates to the effect of impediments to adult or juvenile migration of spring-run Chinook salmon or steelhead, including dams, culverts, channel dewatering, and other structural and channel modifications. Please describe the location of the passage impediment and describe the extent of impediment (i.e., a complete or partial blockage to migration).

### Riparian/Floodplain

This attribute describes the loss of functionality of the riparian forest/vegetation and the connection of the stream to the floodplain during high water and flooding.

## Population Condition Definitions for Section V. Project Objectives—Biological

### Increasing

Adult returns of the target species to the watershed have generally been increasing over the last several years; expectations are that the species is displaying characteristics of a rebuilding or healthy population.

### Stable

Adult returns of the target species to the watershed show no clear trend over the last several years.

### Decreasing

Adult returns of the target species to the watershed are declining over the last several years; the decline in abundance is a cause of concern and characteristic of a potentially unhealthy population.

### Intermittent

Adult returns of the target species are occasionally seen in the watershed, but there is no viable or sustained population in the basin.

### Extirpated

The population has been eliminated from the watershed although the species was present in the past.

### Never Present

The species has never been known to occur in the watershed.

Appendix F3

# Questionnaires received on the Big Chico Creek Action

# Questionnaire

for

# Information on Potential Projects to Support Spring-Run Chinook Salmon and Steelhead in the Sacramento River Basin for the Habitat Expansion Agreement

**DUE: Thursday, April 30, 2009**

**Send completed questionnaires to hea@water.ca.gov**

## I. Contact Information

| | |
|---|---|
| **Name:** | Tracy McReynolds |
| **Organization:** | CA. Dept. of Fish and Game |
| **Address:** | 2545 Zanella Wy. Suite F |
| **City, State, Zip Code:** | Chico, CA 95928 |
| **Phone Number:** | (530) 895-5111 |
| **Email Address:** | tmcreynolds@dfg.ca.gov |

## II. Project Description

| | |
|---|---|
| **Project Name:** | Iron Canyon Fish Ladder Rehabilitation Project |
| **Reference No. or New:** | NS-13 |
| **Project Location:** | The Iron Canyon Fish Ladder is located in Iron Canyon, Upper Bidwell Park, on Big Chico Creek, northeast of Chico, CA, in Butte County. The site is located near the Salmon Hole and Parking Lot P areas of Upper Bidwell Park, accessible from Upper Park Road, a gravel road that roughly parallels the creek, in T22N, R2E, and undesignated section of Arroyo Chico Land Grant. |

**Project Description:**

A massive landslide in the early 1900's blocked spring-run Chinook and steelhead access to holding and spawning habitat above Iron Canyon. In 1958 the California Department of Fish and Game (DFG) constructed the Iron Canyon Fish Ladder to provide access through the blocked area to the nine miles of habitat above Iron Canyon. The ladder is now 50 years old and damage has made fish passage at low flows extremely difficult or impossible.

## II. Project Description

The proposed project would repair existing weirs, expand and modify existing weirs, and install 6 new weirs at the Iron Canyon Fish Ladder (CSU, Chico Research Foundation 2008). The specific construction involves:

• Pool deepening, at minimum of 0.1 feet to 2.1 feet. Excavation of pool sidewalls will be necessary, with large boulder-sized blocks potentially requiring partial or complete removal. Jack-hammer and/or drilling may be necessary for the large block removal. Excavated material does not require removal from the site and may be disposed of in adjacent, non-fishway pools.

• Partial demolition of 18 existing weirs (Weirs 1 through 6, 6B, and 7 through 17). These weirs will then be encased in new reinforced concrete.

• At the contractor's discretion, existing weirs may also be entirely demolished and replaced with new weir design, rather than encased.

• Installation of 6 new weirs (Weirs 1B, 5B, 7B, 8B, 8C, and 11B) constructed with reinforced concrete.

• Installation of fabricated aluminum flashboards into finished weir slots.

The purpose of the project is to improve adult spring-run Chinook and steelhead passage to holding and spawning habitat above Iron Canyon over a broader range of flows.

## III. Species Limiting Factors

**In this section, describe the limiting factors for spring-run Chinook salmon and steelhead in your watershed. The last page of this questionnaire defines the limiting factors.**

| Limiting Factors | Description (from back page) | Rank |
|---|---|---|
| ☐ **Channel Form** | | Select Rank |
| ☐ **Channel Unit Types** | | Select Rank |
| ☐ **Substrate** | | Select Rank |
| ☐ **Structure** | | Select Rank |
| ☒ **Flow** | Agricultural diversions in the Valley reach reduce flows impeding both upstream and downstream passage. | High |
| ☒ **Temperature** | Reduced flows in the Valley reach increase water temperatures and can impact juvenile rearing conditions. | High |
| ☐ **Water Quality** | | Select Rank |
| ☒ **Passage** | The lower reaches have flood control structures and diversions that impede upstream passage when flow is low. | High |
| ☒ **Riparian/Floodplain** | Flood control measures and land use (agricultural and urban) have degraded riperian habitats in the lower reaches | High |

**Source Documents:**

Big Chico Creek Watershed Alliance. Big Chico Creek Existing Conditions Report. Publication date unknown.

Available from http://www.bigchicocreek.org.

**Additional Notes:**

## IV. Project Objectives—Environmental

**In this section, describe how your project will affect one or more of the limiting factors for spring-run Chinook salmon or steelhead described above.**

| Limiting Factor | Description and Objective | Focus |
|---|---|---|
| ☐ **Channel Form** | | Select Focus |
| ☐ **Channel Unit Types** | | Select Focus |
| ☐ **Substrate** | | Select Focus |
| ☐ **Structure** | | Select Focus |
| ☐ **Flow** | | Select Focus |
| ☐ **Temperature** | | Select Focus |
| ☐ **Water Quality** | | Select Focus |
| ☒ **Passage** | The modification will allow the Iron Canyon Fish Ladder to function effectively at flows >= 100cfs. The objective is to improve flow through the fish ladder to facilitate the upstream passage of spring-run Chinook and steelhead over a broader range of flows (HDR and SAGE 2006). | Primary |
| ☐ **Riparian/Floodplain** | | Select Focus |

## V. Project Objectives—Biological

**In this section, describe the objective(s) of your project relative to the goal of providing habitat for spring-run Chinook salmon and steelhead. Indicate the species and life stage that are targeted by the project. (It is okay to have more than one species/life stage target).**

**Target Species:** ☒ Spring-Run Chinook Salmon **Population Status Specific to Watershed:** Relative to Historical

**Target Life Stages:**

☒ Spawning ☐ Egg Incubation ☒ Summer Rearing ☒ Winter Rearing

☐ Juvenile Emigration ☒ Adult Immigration ☒ Adult Holding

**Description of Project Objectives:**

In recent years, the estimated escapement of spring-run Chinook has been less than 200 however past estimates by DFG suggest that Big Chico Creek could support 1000 spring-run Chinook. Repairing the fish ladder would improve spring-run Chinook access to the existing habitat over a broader range of flows thereby increasing escapement in more years. Therefore, one purpose of this project is to increase escapement of spring-run Chinook in Big Chico Creek by improving upstream passage to summer holding, spawning and rearing habitat.

## V. Project Objectives—Biological

**Target Species:** ☒ Steelhead

**Population Status Specific to Watershed:** Relative to Historical

**Target Life Stages:**

☒ Spawning ☐ Egg Incubation ☒ Summer Rearing ☒ Winter Rearing

☐ Juvenile Emigration ☒ Adult Immigration

**Description of Project Objectives:**

Steelhead escapement to Big Chico Creek is currently unknown but historically steelhead were observed in Big Chico Creek. Improvements to the fish ladder would improve access to spawning and juvenile rearing habitat. Therefore another purpose of this project is to increase escapement of steelhead in Big Chico Creek by improving upstream passage to spawning and rearing habitat.

## VI. Project Cost

| | |
|---|---|
| **Capital Cost:** | $1,727,151 (HDR 2007) |
| **Annual Operation and Maintenance Cost:** | Unknown |
| **Annual Operation and Maintenance Description:** | Removing accumulated debris and sediment from pools, installing/uninstalling flashboards, and monitoring movement or deterioration (HDR and SAGE 2006). |
| **Project Lifespan:** | The estimated lifespan of the ladder is 50 years (HDR and SAGE 2006). |
| **Project Partners (Funding):** | USFWS-AFRP (design and environmental compliance). |
| **Project Partners (Maintenance):** | DFG (for basic O&M only). |

## VII. Schedule

| | |
|---|---|
| **Proposed Start:** | Once permits and funding are secured (possibly June 2010). |
| **Expected Time to Completion:** | One work season (June-September) |
| **Expected Time to Realize Environmental Benefits:** | Immediate |
| **Expected Time to Realize Biological Benefits:** | Immediate |

## VIII. Feasibility

| | |
|---|---|
| **Technical Feasibility:** | An evaluation of Iron Canyon for the USFWS was conducted in 2006. Based on the results there was nothing identified geologically, seismically, structurally, or hydraulically to preclude construction of the ladder (HDR and SAGE 2006). |
| **Technical Challenges:** | The work site is located in a steep-walled canyon so site access poses a challenge. There is also a low to moderate risk of a block topple or slide and/or compression failure of sections of the canyon walls. These challenges were addressed in the 2006 evaluation of Iron Canyon. |
| **Related Projects:** | There are numerous restoration project on-going in Big Chico Creek to address passage issues with agricultural diversions and flood control stuctures in the lower portion of the watershed. In addition, a portion of the habitat upstream of Iron Canyon is protected by the Big Chico Creek Ecological Reserve owned by the California State University, Chico Research Foundation. |
| **Ownership or Permitting Challenges:** | The property is owned by the City of Chico. The City of Chico intends to adopt a Mitigated Negative Declaration for the project. No permitting challenges are identified at this time. |
| **Conflicts with Cultural, Zoning, or Other Issues:** | None identified at this time. There are some culutral concerns with cumulative impacts of projects within Big Chico Creek that are expected to be resolved. |

## IX. Project Support

| | |
|---|---|
| **Supporting Entities:** | Big Chico Creek Watershed Alliance (BCCWA) and CSU Chico Research Foundation. |
| **Cooperating Entities:** | USFWS, DFG, and City of Chico. |
| **Degree of Local Support:** | High at this time. |
| **Known Opposition:** | None identified at this time. |

## X. Supporting Documents

**Please provide a full reference for each citation used to support the information presented in this questionnaire.**


CSU, Chico Research Foundation (2008). Iron Canyon Fish Ladder Rehabilitation Initial study/Mitigated Negative Declaration. SCH No. Pending. Prepared for CSU, Chico Research Foundation, USFWS, and City of Chico. August 4, 2008. Chico, CA.

HDR (2007). USFWS - Iron Canyon Fish Ladder Project Construction Documents Project Manual. Prepared for USFWS. June 2007. Folsom, CA.

HDR and SAGE (2006). Evaluation of Iron Canyon for Proposed Fish Ladder Structure Repair and Construction Final Report. Prepared for USFWS Chico, CA. May 2006.

## X. Supporting Documents

## Definitions of Limiting Factors for Spring-Run Chinook Salmon and Steelhead

### Channel Form

This attribute describes changes to the channel, including incision, aggradation, diking, armoring, and other modifications of the channel adversely affecting spring-run Chinook salmon and steelhead.

### Channel Unit Types

Examples of geomorphic features of the channel that form habitat types for spring-run Chinook salmon and steelhead are pools, riffles, glides, and runs. This attribute describes changes in the frequency and size of such features. For example, removal of large wood may reduce the frequency of pools, presence of steps, or retention of gravel for riffles.

### Substrate

This attribute describes changes in the composition of the substrate of the stream, including increase in fine sediment and lack of gravel recruitment.

### Structure

This attribute describes the loss of structural elements in the stream such as large wood, boulders, undercut banks, and so on. Loss of structure results in a simplification of the channel and influences Channel Form and Channel Unit Types.

### Flow

This attribute addresses modification of the flow regime, including decrease in summer low flow, increased "flashiness," and dewatering of the channel as a result of withdrawals.

### Temperature

Change in water temperature can be attributable to human actions such as removal of riparian shading. This attribute describes the increase in summer water temperature and the loss of temperature refugia (springs or groundwater) as a result of human actions.

### Water Quality

This attribute pertains to the input to the stream of toxins or pollutants that produce adverse impacts on spring-run Chinook salmon or steelhead. This can include chemical pollutants such as fertilizer and pesticides and nutrient sources such as cattle and feedlots.

### Passage

This relates to the effect of impediments to adult or juvenile migration of spring-run Chinook salmon or steelhead, including dams, culverts, channel dewatering, and other structural and channel modifications. Please describe the location of the passage impediment and describe the extent of impediment (i.e., a complete or partial blockage to migration).

### Riparian/Floodplain

This attribute describes the loss of functionality of the riparian forest/vegetation and the connection of the stream to the floodplain during high water and flooding.

## Population Condition Definitions for Section V. Project Objectives—Biological

### Increasing

Adult returns of the target species to the watershed have generally been increasing over the last several years; expectations are that the species is displaying characteristics of a rebuilding or healthy population.

### Stable

Adult returns of the target species to the watershed show no clear trend over the last several years.

### Decreasing

Adult returns of the target species to the watershed are declining over the last several years; the decline in abundance is a cause of concern and characteristic of a potentially unhealthy population.

### Intermittent

Adult returns of the target species are occasionally seen in the watershed, but there is no viable or sustained population in the basin.

### Extirpated

The population has been eliminated from the watershed although the species was present in the past.

### Never Present

The species has never been known to occur in the watershed.

# Questionnaire

for

# Information on Potential Projects to Support Spring-Run Chinook Salmon and Steelhead in the Sacramento River Basin for the Habitat Expansion Agreement

**DUE: Thursday, April 30, 2009**

**Send completed questionnaires to hea@water.ca.gov**

## I. Contact Information

| | |
|---|---|
| **Name:** | Susan Strachan |
| **Organization:** | CSU, Chico Research Foundtion |
| **Address:** | Bldg 25, CSU Chico |
| **City, State, Zip Code:** | Chico, CA 95928-0870 |
| **Phone Number:** | 530-894-1308 |
| **Email Address:** | sstrachan@csuchico.edu |

## II. Project Description

| | |
|---|---|
| **Project Name:** | Iron Can yon Fish Ladder Rehabilitation |
| **Reference No. or New:** | New |
| **Project Location:** | Iron Canyo, Big Chico Creek, Chico, Butte County |

**Project Description:**

Rehabilitate existing weirs and install new weirs to provide consistent access to holding and spawning habitat at low to moderate flows.

## III. Species Limiting Factors

**In this section, describe the limiting factors for spring-run Chinook salmon and steelhead in your watershed. The last page of this questionnaire defines the limiting factors.**

| Limiting Factors | Description (from back page) | Rank |
|---|---|---|
| ☐ **Channel Form** | | Select Rank |
| ☐ **Channel Unit Types** | | Select Rank |
| ☐ **Substrate** | | Select Rank |
| ☐ **Structure** | | Select Rank |
| ☐ **Flow** | | Select Rank |
| ☒ **Temperature** | Temperature below Iron Canyon lethal. | High |
| ☐ **Water Quality** | | Select Rank |
| ☒ **Passage** | Iron Canyon boulders obstruct adult passage in low to moderate flow years. Flood control structures can affect adult and juvenile passage. | High |
| ☒ **Riparian/Floodplain** | Urban land use, agricultural land use and flood control modifications have degraded riparian habitat in valley reaches. | Medium |

**Source Documents:**

Big Chico Creek Watershed Alliance, undated.

**Additional Notes:**

## IV. Project Objectives—Environmental

**In this section, describe how your project will affect one or more of the limiting factors for spring-run Chinook salmon or steelhead described above.**

| Limiting Factor | Description and Objective | Focus |
|---|---|---|
| ☐ **Channel Form** | | Select Focus |
| ☐ **Channel Unit Types** | | Select Focus |
| ☐ **Substrate** | | Select Focus |
| ☐ **Structure** | | Select Focus |
| ☐ **Flow** | | Select Focus |
| ☐ **Temperature** | | Select Focus |
| ☐ **Water Quality** | | Select Focus |
| ☒ **Passage** | Project will restore adult passage at low and moderate flows to reach | Primary |

## IV. Project Objectives—Environmental

holding, spawning and rearing habitat.

☐ **Riparian/Floodplain** Select Focus

## V. Project Objectives—Biological

**In this section, describe the objective(s) of your project relative to the goal of providing habitat for spring-run Chinook salmon and steelhead. Indicate the species and life stage that are targeted by the project. (It is okay to have more than one species/life stage target).**

**Target Species:** ☒ Spring-Run Chinook Salmon **Population Status Specific to Watershed:** Intermittent

**Target Life Stages:**

☒ Spawning ☐ Egg Incubation ☒ Summer Rearing ☒ Winter Rearing

☐ Juvenile Emigration ☒ Adult Immigration ☒ Adult Holding

**Description of Project Objectives:**

The estimated escapement of spring-run Chinook is highly variable, ranging from 0 in low flow years to almost 400 in high flow years. Repairing the fish ladder would improve spring-run Chinook access to the existing habitat over a broader range of flows thereby increasing escapement in more years. Therefore one purpose of this project is to increase escapement of spring-run Chinook in Big Chico Creek by improving upstream passage to summer holding, spawning and rearing habitat.

**Target Species:** ☒ Steelhead **Population Status Specific to Watershed:** Intermittent

**Target Life Stages:**

☒ Spawning ☐ Egg Incubation ☒ Summer Rearing ☒ Winter Rearing

☐ Juvenile Emigration ☒ Adult Immigration

**Description of Project Objectives:**

Steelhead escapement to Big Chico Creek is currently unknown but historically steelhead were observed in Big Chico Creek. Improvements to the fish ladder would improve access to spawning and juvenile rearing habitat. Therefore another purpose of this project is to increase escapement of steelhead in Big Chico Creek by improving upstream passage to spawning and rearing habitat.

## VI. Project Cost

**Capital Cost:** $2,114,218 (HDR, 2007, adjusted for 2010 construction costs, grant administration, public outreach and extended construction period for concrete curing)

**Annual Operation and Maintenance Cost:** unknown

## VI. Project Cost

| | |
|---|---|
| **Annual Operation and Maintenance Description:** | Routine operation and maintenance will include inspection, removal of debris, adjustment of flow where possible and small repair such as patching walls where broken or damaged, and other minor repairs necessary to keep fish moving through the ladder (DFG, personal communication) |
| **Project Lifespan:** | 50 years (HDR and Sage, 2006) |
| **Project Partners (Funding):** | USFWS-AFRP (design and environmental compliance) |
| **Project Partners (Maintenance):** | DFG (routine operation and maintenance as described above) |

## VII. Schedule

| | |
|---|---|
| **Proposed Start:** | Bid package fall, 2009, award April 2010, mobilize June 1, 2010 |
| **Expected Time to Completion:** | Complete in channel October 15, 2010, site restoration and contract complete Decemer, 2010 |
| **Expected Time to Realize Environmental Benefits:** | Spring, 2011 |
| **Expected Time to Realize Biological Benefits:** | Spring, 2011 |

## VIII. Feasibility

| | |
|---|---|
| **Technical Feasibility:** | Project selected by agency technical team as preferred alternative (Department of Water Resources, 2002). An evaluation of Iron Canyon for the USFWS was conducted in 2006. Based on the results there was nothing identified geologically, seismically, structurally, or hydraulically to preclude construction of the ladder (HDR and SAGE, 2006). |
| **Technical Challenges:** | The work site is located in a steep-walled canyon so site access poses a challenge. There is also a low to moderate risk of a block topple or slide and/or compression failure of sections of the canyon walls. These challenges were addressed in the 2006 evaluation of Iron Canyon. |
| **Related Projects:** | Agricultural pumps were moved from mouth of Big Chico to Sacramento River to protect juvenile outmigration. Inflatable dam installed at 1-Mile on Big Chico Creek that can be adjusted to improve passage for spring run and steelhead. Ecological Reserve established that protects 4,000 acres of watershed and 4.5 miles of spring run stream habitat. |
| **Ownership or Permitting Challenges:** | CEQA complete. Permitting underway, expected to be complete by fall, 2009. |
| **Conflicts with Cultural, Zoning, or Other Issues:** | Cultural resources survey documented no cultural conflicts. Project is consistent with City of Chico planning documents. |

## IX. Project Support

| | |
|---|---|
| **Supporting Entities:** | City of Chico, CSU, Chico Research Foundation, Big Chico Creek Watershed Alliance |
| **Cooperating Entities:** | DFG, USFWS, NMFS |
| **Degree of Local Support:** | High |
| **Known Opposition:** | None |

## X. Supporting Documents

**Please provide a full reference for each citation used to support the information presented in this questionnaire.**

All documents except construction specifications can be found at http://www.bigchicocreek.org/nodes/aboutwatershed/projectsprograms/iron_canyon_fish_ladder.htm

Big Chico Creek Watershed Alliance, undated. Existing Conditions Report. Chico, CA. Undated.

Department of Water Resources (2002). Iron Canyon and Bear Hole Fish Passage Project on Big Chico Creek, Preliminary Engineering Technical Report. Sacramento, CA. April 2002.

HDR (2007). USFWS - Iron Canyon Fish Ladder Project Construction Documents Project Manual. Prepared for USFWS. June 2007. Folsom, CA.

HDR and SAGE (2006). Evaluation of Iron Canyon for Proposed Fish Ladder Structure Repair and Construction Final Report. Prepared for USFWS Chico, CA. May 2006.

## Definitions of Limiting Factors for Spring-Run Chinook Salmon and Steelhead

### Channel Form

This attribute describes changes to the channel, including incision, aggradation, diking, armoring, and other modifications of the channel adversely affecting spring-run Chinook salmon and steelhead.

### Channel Unit Types

Examples of geomorphic features of the channel that form habitat types for spring-run Chinook salmon and steelhead are pools, riffles, glides, and runs. This attribute describes changes in the frequency and size of such features. For example, removal of large wood may reduce the frequency of pools, presence of steps, or retention of gravel for riffles.

### Substrate

This attribute describes changes in the composition of the substrate of the stream, including increase in fine sediment and lack of gravel recruitment.

### Structure

This attribute describes the loss of structural elements in the stream such as large wood, boulders, undercut banks, and so on. Loss of structure results in a simplification of the channel and influences Channel Form and Channel Unit Types.

### Flow

This attribute addresses modification of the flow regime, including decrease in summer low flow, increased "flashiness," and dewatering of the channel as a result of withdrawals.

### Temperature

Change in water temperature can be attributable to human actions such as removal of riparian shading. This attribute describes the increase in summer water temperature and the loss of temperature refugia (springs or groundwater) as a result of human actions.

### Water Quality

This attribute pertains to the input to the stream of toxins or pollutants that produce adverse impacts on spring-run Chinook salmon or steelhead. This can include chemical pollutants such as fertilizer and pesticides and nutrient sources such as cattle and feedlots.

### Passage

This relates to the effect of impediments to adult or juvenile migration of spring-run Chinook salmon or steelhead, including dams, culverts, channel dewatering, and other structural and channel modifications. Please describe the location of the passage impediment and describe the extent of impediment (i.e., a complete or partial blockage to migration).

### Riparian/Floodplain

This attribute describes the loss of functionality of the riparian forest/vegetation and the connection of the stream to the floodplain during high water and flooding.

## Population Condition Definitions for Section V. Project Objectives—Biological

### Increasing

Adult returns of the target species to the watershed have generally been increasing over the last several years; expectations are that the species is displaying characteristics of a rebuilding or healthy population.

### Stable

Adult returns of the target species to the watershed show no clear trend over the last several years.

### Decreasing

Adult returns of the target species to the watershed are declining over the last several years; the decline in abundance is a cause of concern and characteristic of a potentially unhealthy population.

### Intermittent

Adult returns of the target species are occasionally seen in the watershed, but there is no viable or sustained population in the basin.

### Extirpated

The population has been eliminated from the watershed although the species was present in the past.

### Never Present

The species has never been known to occur in the watershed.

Appendix F4

# Questionnaire received on the Battle Creek Actions

# Questionnaire

for

# Information on Potential Projects to Support Spring-Run Chinook Salmon and Steelhead in the Sacramento River Basin for the Habitat Expansion Agreement

**DUE: Friday, February 13, 2009**

**Send completed questionnaires to hea@water.ca.gov**

## I. Contact Information

| | |
|---|---|
| **Name:** | Mike Berry |
| **Organization:** | California Department of Fish and Game |
| **Address:** | 601 Locust Street |
| **City, State, Zip Code:** | Redding, CA 96001 |
| **Phone Number:** | 530-225-2131 |
| **Email Address:** | mberry@dfg.ca.gov |

## II. Project Description

| | |
|---|---|
| **Project Name:** | Battle Creek Restoration Project |
| **Reference No. or New:** | B-1 and B-2. |
| **Project Location:** | Tehama County, approximately 2 miles South of the town of Manton |

**Project Description:**

Financial support of implementation of Phase 1(b) of the Battle Creek Restoration Project. Phase 1(b) includes a new tailrace connector from Inskip powerhouse to Coleman Canal and a water bypass channel near Inskip Powerhouse. This phase potentially includes removal of Coleman Diversion Dam, depending on the timing of the completion of Phase 2. The project also includes financial support of implementation of Phase 2 of the Battle Creek Restoration Project. Phase 2 includes removing Coleman Diversion Dam (if not completed in Phase1(b)), South, Lower Ripley Creek Feeder, and Soap Creek Feeder Diversion Dams; installing screens and ladders on Inskip Diversion Dam; a tailrace connector from South Powerhouse to Inskip Canal and decommisioning South Canal.

## III. Species Limiting Factors

**In this section, describe the limiting factors for spring-run Chinook salmon and steelhead in your watershed. The last page of this questionnaire defines the limiting factors.**

| Limiting Factors | Description (from back page) | Rank |
|---|---|---|
| ☐ **Channel Form** | | Select Rank |
| ☐ **Channel Unit Types** | | Select Rank |
| ☐ **Substrate** | | Select Rank |
| ☐ **Structure** | | Select Rank |
| ☒ **Flow** | The flow in South Fork Battle Creek is reduced to 3-5 cubic feet per second (cfs) due to diversions for hydro-power, thus severely limiting habitat for all life stages of spring-run Chinook salmon and steelhead. | Critical |
| ☒ **Temperature** | Because of the reduced flow, water temperatures increase to levels lethal to all life stages of spring-run Chinook salmon and steelhead | High |
| ☐ **Water Quality** | | Select Rank |
| ☒ **Passage** | The diversion dams have ladders that are to small or are in poor condition and therefore block spring-run Chinook salmon and steelhead access to approximately 16.3 miles of prime habitat. | Critical |
| ☐ **Riparian/Floodplain** | | Select Rank |

**Source Documents:**

Battle Creek Restoration Project EIS/EIR (2005), Battle Creek Salmon and Steelhead Restoration Plan (1999).

**Additional Notes:**

## IV. Project Objectives—Environmental

**In this section, describe how your project will affect one or more of the limiting factors for spring-run Chinook salmon or steelhead described above.**

| Limiting Factor | Description and Objective | Focus |
|---|---|---|
| ☐ **Channel Form** | | Select Focus |
| ☐ **Channel Unit Types** | | Select Focus |
| ☐ **Substrate** | | Select Focus |
| ☐ **Structure** | | Select Focus |
| ☒ **Flow** | When the project is completed flow will be increased downstream of Inskip Diversion Dam from the current 3-5 cfs up to 35-40 cfs. Upstream of Inskip Diversion Dam the flows will increase to natural | Primary |

## IV. Project Objectives—Environmental

| | | |
|---|---|---|
| | flows because South Diversion Dam will have been removed. | |
| ☒ **Temperature** | The increased flow will lower the temperatures in Battle Creek to levels capable of supporting all life stages of spring-run Chinook salmon and steelhead, including incubation of eggs. | Primary |
| ☐ **Water Quality** | | Select Focus |
| ☒ **Passage** | Removal of two dams and a new fish ladder at Inskip Diversion Dam will allow access to 16.3 miles of prime spring-run Chinook and steelhead habitat that has not been used since the early 1900's when the hydro-electric projects were first built. Construction of a State and federally approved fish screen will allow safe passage of emmigrating juveniles passed the diversion canal. | Primary |
| ☒ **Riparian/Floodplain** | The increased flow and additional nutrients from decaying salmon carcasses will likely result in healthier riparian forest/vegetation. | Secondary |

## V. Project Objectives—Biological

**In this section, describe the objective(s) of your project relative to the goal of providing habitat for spring-run Chinook salmon and steelhead. Indicate the species and life stage that are targeted by the project. (It is okay to have more than one species/life stage target).**

**Target Species:** ☒ Spring-Run Chinook Salmon **Population Status Specific to Watershed:** Extirpated

**Target Life Stages:**

☒ Spawning ☒ Egg Incubation ☒ Summer Rearing ☒ Winter Rearing

☒ Juvenile Emigration ☒ Adult Immigration ☒ Adult Holding

**Description of Project Objectives:**

In the early 1900's several dams were built on Battle Creek as part of a hydro-electric power production project. The dams on South Fork Battle Creek diverted a majority of the water out of this tributary and blocked passage of adult spring-run Chinook salmon. Completing Phase 1(b) and Phase 2 of the project will restore water flow, temperature, and spring-run Chinook salmon access to16.3 miles of prime historic spring-run Chinook salmon habitat. Additionally the project will restore optimum water temperatures for egg incubation, juvenile rearing, and outmigrating smolts while screening the diversion will prevent emegrating juveniles from being drawn into the canal.

**Target Species:** ☒ Steelhead **Population Status Specific to Watershed:** Intermittent

**Target Life Stages:**

☒ Spawning ☒ Egg Incubation ☒ Summer Rearing ☒ Winter Rearing

☒ Juvenile Emigration ☒ Adult Immigration

**Description of Project Objectives:**

[Same as Above for Spring-Run Chinook Salmon]

## VI. Project Cost

| | |
|---|---|
| **Capital Cost:** | Phase 1(b) cost estimate is $26 million, Phase 2 cost estimate is $47 million, we are recommending approximately $30 million of HEA money that will be matched with other funds. |
| **Annual Operation and Maintenance Cost:** | Not estimated |
| **Annual Operation and Maintenance Description:** | Not estimated |
| **Project Lifespan:** | Perpetuity |
| **Project Partners (Funding):** | Possibly California Department of Fish and Game (CDFG), California Wildlife Conservation Board (WCB), California Department of Water Resources (DWR), Pacific Gas and Electric Company (PG&E), and/or Bureau of Reclamation (Reclamation). |
| **Project Partners (Maintenance):** | PG&E will own and maintain all of the improvements and related hydro-power facilities, and have agreed to maintain them in working order. |

## VII. Schedule

| | |
|---|---|
| **Proposed Start:** | Summer 2010 |
| **Expected Time to Completion:** | 2-4 years |
| **Expected Time to Realize Environmental Benefits:** | Immediately after completion. |
| **Expected Time to Realize Biological Benefits:** | First winter and spring after completion, full benefit after a few generations of returning Chinook salmon and steelhead. Spring-run Chinook salmon and steelhead are present in the drainage downstream of the dam, and are expected to occupy the newly opened habitat during their first adult migration event after completion. |

## VIII. Feasibility

| | |
|---|---|
| **Technical Feasibility:** | This project is very feasable, the feasability studies are complete, engineering and design is complete and the various environmental documents are complete. |
| **Technical Challenges:** | None that have not been identified and adequately addressed. |
| **Related Projects:** | North Fork Battle Creek restoration is scheduled to start in the Summer of 2009 (Phase 1(a)) and will provide access and suitable habitat for spring-run Chinook salmon and steelhead to 11 miles of North Fork Battle Creek. |
| **Ownership or Permitting Challenges:** | There is one landowner near Inskip Dam that is unhappy with various aspects of the project. PG&E continues to work with them to resolve the issues. |

## VIII. Feasibility

| | |
|---|---|
| **Conflicts with Cultural, Zoning, or Other Issues:** | None known |

## IX. Project Support

| | |
|---|---|
| **Supporting Entities:** | DWR, Regional Water Quality Control Board, State Water Resources Control Board, The Nature Conservancy, Metropolitan Water District, Battle Creek Watershed Conservancy, Nor-Cal Fishing Guides and Sportsman Assn., U.S. Forest Service, Lassen National Forest |
| **Cooperating Entities:** | CDFG, PG&E, Reclamation, U.S. Fish and Wildlife Service, NOAA Fisheries. |
| **Degree of Local Support:** | High |
| **Known Opposition:** | Oasis Springs Lodge |

## X. Supporting Documents

**Please provide a full reference for each citation used to support the information presented in this questionnaire.**

Kier Associates. 1999. Battle Creek Salmon and Steelhead Restoration Plan. Prepared for the Greater Battle Creek Watershed Working Group. January. Sausalito, CA.

Jones and Stokes. 2005. Battle Creek Salmon and Steelhead Restoration Project Final Environmental Impact Statement/Environmental Report. July. Sacramento, CA.

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### Intermittent

Adult returns of the target species are occasionally seen in the watershed, but there is no viable or sustained population in the basin.

### Extirpated

The population has been eliminated from the watershed although the species was present in the past.

Appendix G

# Habitat Expansion for Spring-run Chinook Salmon and Steelhead in the Lower Yuba River

Prepared for the HEA Steering Committee by Members of the Yuba Accord River Management Team

# HABITAT EXPANSION FOR SPRING-RUN CHINOOK SALMON AND STEELHEAD IN THE LOWER YUBA RIVER

**Prepared for the HEA Steering Committee**

## INTRODUCTION

Representatives of the Habitat Expansion Agreement (HEA) Steering Committee provided the Yuba Accord River Management Team (RMT) with an overview of the HEA project evaluation, selection and approval process. In response to the HEA Steering Committee's request for additional information regarding biological, physical and operational considerations pertinent to the lower Yuba River, the HEA Steering Committee and the Yuba Accord RMT held an informal technical workshop on October 6, 2009. Background information relevant to the lower Yuba River was provided to the HEA Steering Committee, and project-specific implementation considerations were discussed. HEA Steering Committee provided the RMT with a list of questions regarding habitat expansion issues on the lower Yuba River. Subsequent to the HEA Steering Committee and the Yuba Accord RMT informal technical workshop, the RMT conducted a field tour of the lower Yuba River on October 7, 2009 and reviewed and further discussed potential habitat expansion projects.

The RMT does not feel that it would be appropriate to provide comments as a group. Members of the RMT have different views and perspectives about some habitat restoration measures, and may choose to provide comments on behalf of their respective agencies. However, some of the members of the RMT did work together to draft comments for the HEA Steering Committee, and to provide some feedback on the questions posed. Those comments are incorporated into this document.

The Yuba Accord RMT membership includes Yuba County Water Agency (YCWA), California Department of Fish and Game (CDFG), National Marine Fisheries Service (NMFS), U.S. Fish and Wildlife Service (USFWS), the South Yuba River Citizens League (SYRCL), the Bay Institute, Friends of the River, Trout Unlimited, PG&E, and Department of Water Resources (DWR), with the collaboration of the Pacific States Marine Fisheries Commission (PSMFC) and University of California at Davis (UC Davis). RMT responsibilities include providing input to real-time operational decisions, developing and implementing a Monitoring and Evaluation Program (M&E Program), and guiding the implementation of specific habitat restoration pilot projects. Using revenues generated by the water transfer program component of the Yuba Accord, YCWA is providing $6 million (about $550,000 annually) to implement the M&E

Program, and an additional $300,000 of funding dedicated to development and implementation of pilot restoration projects.

# BACKGROUND

## GOALS OF THE HABITAT EXPANSION AGREEMENT

The overall goal of the HEA is to expand the amount of habitat with the physical characteristics necessary to support spawning, rearing and adult holding of spring-run Chinook salmon (and steelhead) in the Sacramento River Basin. The specific Habitat Expansion Threshold (HET) is to expand spawning, rearing and adult habitat sufficiently to accommodate an estimated net increase of 2,000 to 3,000 spring-run Chinook salmon for spawning in the Sacramento River Basin. The HET is focused on spring-run Chinook salmon as the priority species, because expansion of habitat for spring-run Chinook salmon typically accommodates steelhead as well.

## LOWER YUBA RIVER POTENTIAL TO MEET IDENTIFIED HABITAT EXPANSION AGREEMENT GOALS AND THRESHOLDS

The lower Yuba River supports persistent populations of spring-run Chinook salmon and steelhead, and historically supported the largest, naturally-reproducing population of steelhead in the Central Valley (CDFG 1996). The lower Yuba River is among the last Central Valley floor tributaries supporting populations of naturally-spawning spring-run Chinook salmon and steelhead.

The lower Yuba River, extending approximately 24 miles from Englebright Dam downstream to the confluence with the Feather River near Marysville, is the largest river in the Central Valley not supported by a hatchery (**Figure 1**). The lower Yuba River has a high potential to meet the HEA goals and thresholds, and to meet the NMFS recovery objectives of supporting a viable independent population of spring-run Chinook salmon (and steelhead) primarily because: (1) the river continues to support persistent populations of spring-run Chinook salmon and steelhead; (2) flow and water temperature conditions under the Lower Yuba River Accord are suitable to support all life stage requirements; (3) the river does not have a hatchery on it; and (4) high habitat enhancement potential. These attributes are particularly important when considering long-term climate change (discussed below).

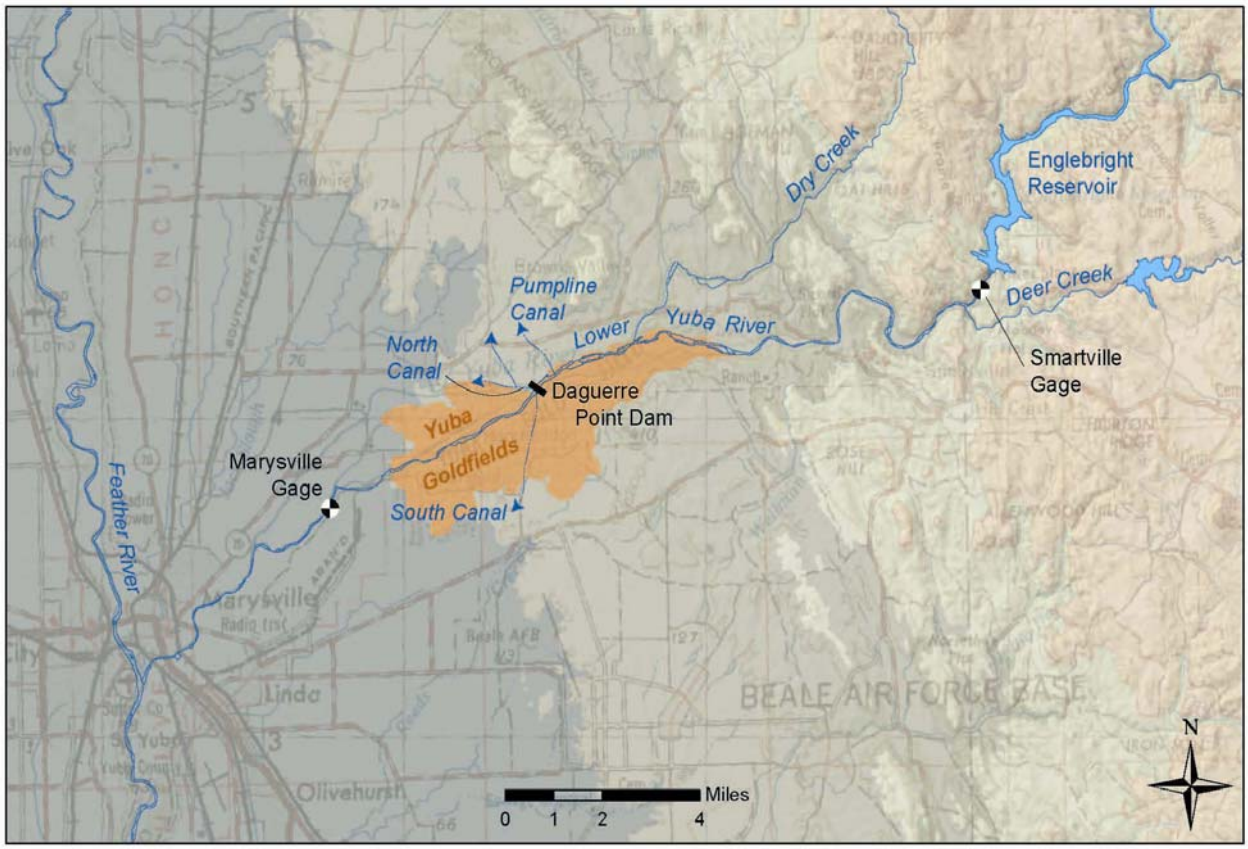



**Figure 1. Lower Yuba River**

The NMFS (2009) Public Draft Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-run Chinook Salmon and Central Valley Spring-run Chinook Salmon, and the Distinct Population Segment of Central Valley Steelhead ("Draft Recovery Plan") recognizes the importance and potential to increase spring-run Chinook salmon and steelhead populations in the lower Yuba River. The Draft Recovery Plan established three priority levels to help guide recovery efforts for watersheds that are currently occupied, and are referred to as Core 1, 2, and 3 populations. Core 1 Populations are highest priority, have a known ability or potential to support viable populations, and have the capacity to respond to recovery actions (NMFS 2009). Spring-run Chinook salmon and steelhead in the lower Yuba River are Core 1 populations (NMFS 2009). Core 1 populations form the foundation of the recovery strategy, and should be the first focus of an overall recovery effort (NMFS 2009).

The Draft Recovery Plan states that "*…many of the processes and conditions that are necessary to support a viable independent population of spring-run Chinook salmon can be improved with provision of appropriate instream flow regimes, water temperatures, and habitat availability. Continued implementation of the Yuba Accord is expected to address these factors and considerably improve conditions in the lower Yuba River*".

After two one-year pilot programs in 2006 and 2007, on March 18, 2008 the State Water Resources Control Board (SWRCB) approved the consensus-based, comprehensive Yuba Accord to protect and enhance aquatic habitat in the lower Yuba River. The Yuba Accord will be in effect at least until 2016. Beyond 2016, it is anticipated that the Lower Yuba River Accord flow schedules will be the basis of new FERC license requirements for the lower Yuba River.

Presently, the lower Yuba River is one of the few Central Valley floor tributaries that consistently provides suitable water temperatures for salmonids throughout the year. In fact, water temperature evaluations conducted for the Yuba Accord EIR/EIS indicate that Yuba River water temperatures generally remain suitable for all life stages of spring-run Chinook salmon and steelhead. Water temperatures generally remain below 58°F year-round (including summer months) at Smartsville, and below 60°F year-round at Daguerre Point Dam (YCWA *et al.* 2007). At Marysville, water temperatures generally remain below 60°F from October through May, and below 65°F from June through September (YCWA *et al*. 2007).

## Habitat Conditions

Major factors (not directly flow-related) continuing to influence the status of naturally-spawning spring-run Chinook salmon and steelhead in the Yuba River include: (1) blockage of historic spawning habitat resulting from the construction of the U.S. Corp of Engineers (Corps) Englebright Dam in 1941, which has implications for the spatial structure of the populations; (2) impaired adult upstream passage at the Corps Daguerre Point Dam; (3) unsuitable spawning conditions in the uppermost area (i.e., Englebright Dam to the Narrows) of the lower Yuba River; and (4) impaired juvenile downstream passage at Daguerre Point Dam. Additionally, other factors continue to influence juvenile spring-run Chinook salmon and steelhead habitat suitability including sparse and restricted amounts of riparian vegetation and associated instream object and overhanging object cover, limited aquatic habitat complexity and diversity, and altered natural river function and morphology in the lower Yuba River (CALFED and YCWA 2005).

The section of the lower Yuba River extending from Englebright Dam downstream through the Narrows (Englebright Dam Reach) is steep and contains a series of rapids, runs, and deep pools confined by a bedrock canyon (CALFED and YCWA 2005). Habitats classified as moderate gradient riffles are found only in this reach of the lower Yuba River (CALFED and YCWA 2005). Salmonid spawning gravels are scarce in the Englebright Dam Reach due to the truncation of gravel recruitment resulting from the construction of Englebright Dam and the high-energy hydraulic nature of this reach. Furthermore, the quantity and quality of salmonid spawning habitat in this reach has been significantly reduced by the deposition of large, consolidated rock fragments (i.e., “shot-rock”) downstream of Englebright Dam, resulting from dam construction and hillside landslides during major floods (Pasternack 2009). Additionally, local instream gravel mining has influenced potential spawning habitat in this reach.

Downstream of the Englebright Dam Reach, spawning gravels are abundant and generally of high quality throughout the lower Yuba River with the exception of the lowermost reach (Simpson Lane Reach) (YCWA *et al.* 2000).

Although montane hardwoods occupy much of the Englebright Dam Reach, the steep-walled canyons preclude riparian growth immediately adjacent to the river channel, thereby affecting aquatic habitat suitability (CALFED and YCWA 2005). In the vicinity of Daguerre Point Dam, the lower Yuba River is largely devoid of sufficient riparian vegetation commonly associated with highly suitable juvenile salmonid rearing habitat conditions (CALFED and YCWA 2005). The Yuba Goldfields area, comprised of approximately 11,000 acres of land adjoining the lower Yuba River near Daguerre Point Dam, is the result of intensive gold dredging in the late 1800s and early 1900s when up to 27 gold dredges simultaneously operated along the river and floodplain (Smith 1990). The Yuba Goldfields section near Daguerre Point Dam is largely devoid of streamside vegetation.

Shaded riverine aquatic (SRA) habitat generally occurs in the lower Yuba River as scattered, short strips of low-growing woody species (e.g., *Salix sp*.) adjacent to the shoreline (CALFED and YCWA 2005). The most extensive and continuous segments of SRA habitat occur along bars where recent channel migrations or avulsions have cut new channels through stands of riparian vegetation. Due to a lack of riparian vegetation throughout much of the lower Yuba River, coupled with Englebright Dam precluding the downstream transport of woody material, instream woody material also is limited in the lower Yuba River (CALFED and YCWA 2005).

In recent years, another factor influencing the status of naturally-spawning spring-run Chinook salmon and steelhead in the lower Yuba River included flow fluctuations (YCWA *et al.* 2007; CALFED and YCWA 2005). However, since the issuance of the SWRCB Yuba Accord Decision, a full-flow bypass structure has been installed on the Narrows II hydropower facility which will essentially eliminate the potential for flow fluctuations to occur in the lower Yuba River associated with maintenance and operation of the Narrows II facility.

## MONITORING AND EVALUATION

Anadromous salmonid management in California's Central Valley suffers from the lack of sufficiently-funded, comprehensive, and sustained monitoring programs. The lower Yuba River is unique among Central Valley Rivers in that an ongoing monitoring and evaluation program, based on quantified expressions of the viable salmonid population (VSP) concept, provides the opportunity to develop and evaluate the implementation of habitat expansion projects.

The Yuba Accord includes a Fisheries Agreement, under which YCWA cooperatively manages the flows of the lower Yuba River according to certain specified criteria, and provides $550,000 of annual funding for monitoring and evaluation of fish populations (including spring-run Chinook salmon and steelhead), aquatic habitat conditions, and fish-habitat interactions through

the year 2016. Additionally, extensive in-kind contributions from YCWA and CDFG, plus solicitation of grant funding when available, further extend the monitoring and evaluation budget.

The Yuba Accord River Management Fund is administered by the RMT, which has developed and is implementing the Yuba Accord M & E Program. Because of the complexity associated with the multiple considerations for monitoring and evaluation efforts within the lower Yuba River, the M&E Program framework is designed to evaluate whether implementation of the Yuba Accord maintains fish in good condition, and promotes viable salmonid populations in the lower Yuba River.

McElhany *et al.* (2000) developed the "Viable Salmonid Population" (VSP) concept to facilitate establishment of Evolutionarily Significant Unit (ESU)-level delisting goals and to assist in recovery planning by identifying key parameters related to population viability. As presented in Good *et al.* (2007), criteria for viable salmonid populations (VSP) are based upon measures of population parameters that reasonably predict extinction risk and reflect processes important to populations: (1) abundance; (2) productivity; (3) diversity; and (4) spatial structure (McElhany *et al.* 2000). Abundance is critical, because small populations are generally at greater risk of extinction than large populations. Stage-specific or lifetime productivity (i.e., population growth rate) provides information on important demographic processes. Abundance and productivity data are used to asses the status of populations of threatened and endangered ESUs (Good *et al.* 2005). Genotypic and phenotypic diversity are important in that they allow species to use a wide array of environments, respond to short-term changes in the environment, and survive long-term environmental change. Spatial structure reflects how abundance is distributed among available or potentially available habitats and how it can affect overall extinction risk and evolutionary processes that may alter a population's ability to respond to environmental change.

In the M&E Program, performance indicators associated with each of the VSP parameters (Abundance, Productivity, Diversity and Spatial Structure) and analytical steps ("analytics") to address each of these performance indicators are provided separately for the adult and juvenile lifestages of the anadromous salmonids, including spring-run Chinook salmon and steelhead, in the lower Yuba River. Completed, ongoing, or planned M&E Program activities include the following:

- Flow and Water Temperature Monitoring
- Morphological Unit & Mesohabitat Classification
- Substrate and Cover Classification and Mapping
- Topographic Mapping
- Development of a Digital Elevation Model of the entire 24 miles of the lower Yuba River
- Development of a 2-D Hydraulic Model
- Acoustic Tracking of Phenotypic Spring-run Chinook Salmon

- Genetic Analysis of Spring-run and Fall-run Chinook Salmon
- Chinook Salmon Escapement (Carcass) Surveys
- Adult Salmonid Biological Sampling (otoliths, scales, tissue, CWT)
- VAKI Riverwatcher System Monitoring of Fish Passage at Corps' Daguerre Point Dam
- Angler Surveys
- Redd (and Superimposition) Surveys
- Juvenile Outmigration Rotary Screw Trapping
- Juvenile Habitat Utilization Snorkel Surveys

Information obtained through the Yuba Accord M&E Program provides a basis to develop and consider habitat expansion projects in the lower Yuba River, within the context of the HET and expanded habitat utilization. Additionally, the Yuba Accord M&E Program will serve as a baseline for the future evaluation of habitat expansion projects in the lower Yuba River and, if lower Yuba River habitat expansion projects are implemented in a timely fashion, the Yuba Accord M&E Program could directly evaluate population response, as well as serve as a baseline.

# LOWER YUBA RIVER HABITAT EXPANSION CONSIDERATIONS

The intent of the HEA is to create "permanent" solutions to problems, or at least to provide benefits through the term of a typical Federal Energy Regulatory Commission license (i.e., up to 50 years). Where possible, projects should address the root cause of current habitat constraints rather than dealing with their symptoms or surface expression, and should consider the potential effects of climate change.

## CLIMATE CHANGE AND HABITAT EXPANSION SUSTAINABILITY

The scientific, political, and public priorities associated with long-term climate change are evolving toward determining its ecosystem impacts, and developing strategies for adapting to those impacts.

Studies suggest that up to 40 percent of Pacific Northwest salmon populations may be lost by 2050 (Battin *et al.* 2007). In California and the Pacific Northwest, most wild salmon populations are extinct or imperiled in 56 percent of their historical range (Francis and Mantua 2003). Studies also suggest that about one-third of the current habitat for salmon and other coldwater fish will no longer be suitable for them by the end of this century as key temperature thresholds are exceeded (Thomas *et al.* 2009). Because climate change impacts on salmon and steelhead habitat is projected to be negative, climate change is expected to hinder efforts to recover depleted

populations of Chinook salmon and steelhead (Thomas *et al.* 2009). Climate change also could be reasonably expected to affect the sustainability of habitat expansion projects in the Central Valley.

In California, there have been observed changes in air temperatures, annual precipitation, runoff, and sea levels over the past century (Anderson *et al.* 2008). Regional-scale climate models for California are in broad agreement that temperatures in the future will warm significantly, total precipitation may decline, and snowfall will decline significantly (Lindley *et al.* 2007). Literature suggests that by 2100, mean summer temperatures in the Central Valley may increase by 2 to 8°C, precipitation will likely shift to more rain and less snow, with significant declines in total precipitation possible, and hydrographs will likely change, especially in the southern Sierra Nevada mountains. Thus, climate change poses an additional risk to the survival of salmonids in the Central Valley.

Long-term climate change considerations emphasize the importance of implementing habitat expansion projects in locations where they would be expected to be sustainable. The lower Yuba River has a high potential to sustain spring-run Chinook salmon and steelhead populations, primarily because of suitable flows and the consistent flow of cold water.

The lower Yuba River is expected to provide the most suitable water temperature conditions for anadromous salmonids, of all Central Valley floor rivers, in consideration of long-term climate change because of specific physical and hydrologic factors. New Bullards Bar Reservoir is a deep, steep-sloped reservoir with ample coldwater pool reserves. Throughout the period of operations of New Bullards Bar Reservoir (1969 through present), which encompasses the most extreme critically dry year on record (1977), the coldwater pool in New Bullards Bar Reservoir has not been depleted. Since 1993, coldwater pool availability in New Bullards Bar Reservoir has been sufficient to accommodate year-round utilization of the lower river outlets at the direction provided by CDFG in order to provide cold water to the lower Yuba River.

## RECOVERY ACTIONS AND HABITAT EXPANSION PROJECTS

The conceptual recovery scenarios for spring-run Chinook salmon and steelhead in the Draft Recovery Plan include: (1) securing extant populations by implementing key habitat restoration actions, particularly in the near term; and (2) establishing additional viable independent populations.

In order to secure viable independent populations of spring-run Chinook salmon and steelhead in the lower Yuba River, the Draft Recovery Plan identified several key near-term and long-term habitat restoration actions, including the following:

- Continue implementation of the Yuba Accord flow schedules to provide suitable habitat (flow and water temperature) conditions for all life stages
- Implement a spawning habitat rehabilitation program in the uppermost area (i.e., Englebright Dam to the Narrows) of the lower Yuba River
- Improve riparian habitats for juvenile salmonid rearing
- Create and restore side-channel habitats to increase the quantity and quality of off-channel rearing (and spawning) areas
- Implement projects to increase floodplain habitat availability to improve habitat conditions for juvenile rearing
- Improve adult and juvenile salmonid passage at Daguerre Point Dam

According to HEA Evaluation Criterion (b), a number of projects might need to be concentrated in a single watershed to result in sufficient environmental change to meet the HET.

The HEA Steering Committee considered several individual habitat expansion actions in combination for the lower Yuba River. The HEA Steering Committee considered integration of these actions because they believed that the actions potentially benefited each other. The following actions are being considered by the HEA Steering Committee for the lower Yuba River:

- Spawning habitat rehabilitation of the Englebright Dam Reach, including Deer Creek
- Side channel, floodplain and riparian habitat restoration
- Operation of a segregation weir in the 6-mile reach between the Highway 20 Bridge and Englebright Dam
- Fish passage improvements at Daguerre Point Dam

Total funding availability, engineering feasibility, operations and maintenance, and action sustainability may require consideration of the priority of specific actions within the suite of potential actions for the lower Yuba River, and consideration of each action's ability to achieve biological benefit and accomplishment of the goals of the HEA. For example, two of the four actions directly address the overall goal of the HEA, which is to expand the amount of habitat with the physical characteristics necessary to support spawning, rearing and adult holding of spring-run Chinook salmon and steelhead in the Sacramento River Basin: (1) spawning habitat rehabilitation of the Englebright Dam Reach; and (2) side channel, floodplain and riparian habitat restoration.

The two remaining actions do not directly address the overall goal of the HEA: (3) operation of a segregation weir in the 6-mile reach between the Highway 20 Bridge and Englebright Dam; and (4) fish passage improvements at Daguerre Point Dam.

- Design, construction, operation and maintenance of a segregation weir does not, unto itself, expand habitat. Rather, the stated intent is to accomplish geographic distinction and

thereby reduce the potential for genetic introgression between fall-run Chinook salmon and spring-run Chinook salmon.

- Although improved fish passage at Daguerre Point Dam would help to facilitate access to available upstream habitat, it would not expand the amount of habitat with the physical characteristics necessary to support spawning, rearing and adult holding of spring-run Chinook salmon and steelhead.

## Spawning Habitat Rehabilitation of the Englebright Dam Reach, Including Deer Creek

Englebright Dam was constructed by the Corps in 1941 on the lower Yuba River to trap hydraulic mining debris resulting from the gold rush in California. The dam has been blocking the natural recruitment of spawning gravels in the Englebright Dam Reach, extending approximately 0.8 miles downstream from Englebright Dam to the confluence with Deer Creek, for over 65 years. In many areas of this reach, the spawning gravels are completely absent and have been replaced by a bedrock substrate. Spring-run Chinook salmon have been observed to migrate and hold in this area of river, but spawning success has been largely impacted by a lack of suitable spawning habitat.

The Englebright Dam Reach spawning habitat rehabilitation component is highly feasible, based upon a 5-year (2003-2008) comprehensive investigation conducted to ascertain the linkages between hydrology, geomorphology, and ecology (Pasternack 2009), and a 2007 pilot gravel injection study. Pasternack (2009) highly recommended that spawning habitat rehabilitation in this reach be designed using the Spawning Habitat Integrated Rehabilitation Approach (SHIRA) that is in use on the Feather, American, Trinity, and Mokelumne Rivers. For details, see the website at http://shira.lawr.ucdavis.edu. Using SHIRA would ensure that a project of this magnitude would immediately yield spawning habitat, as has been thoroughly documented on the Mokelumne and Trinity rivers.

There are three shot-rock deposits in the Englebright Dam Reach. First, an extremely coarse and thin veneer occurs at the upper end of the reach on river right. Second, angular cobble forming a bar is located just upstream of the USGS Gaging Station rapid that impacts the gaging station every time there is a flood. Third, a mixture of angular gravel, cobbles, and boulders is located upstream of the junction with Deer Creek on river right. This deposit is called Sinoro Bar. Thus, there are two big deposits on river right and one small deposit on river left (Pasternack 2009).

To yield high quality Chinook spawning habitat in the Englebright Dam Reach, Pasternack (2009) stated that a spawning habitat rehabilitation project must accomplish two things. First, it must remove the massive amount of shot-rock off of Sinoro Bar, returning that entire point bar to the elevation of the water's surface at approximately 800 cfs. Second, it must place suitable spawning gravel into the river, substantially filling in the present channel and changing site-

specific hydraulic characteristics to new suitable patterns. Shot-rock removal, localized grading, and gravel injection will improve spawning habitat by restoring natural channel morphological units, restoring natural channel form and unit types synonymous with spawning habitat values (i.e. pool, riffle, bank structure, LWD retention, etc.), and restoring natural spawning substrate absent in this reach. Once spawning habitat rehabilitation is performed in this reach, it would be possible to sustain the project using gravel injection at the upper portion of this reach (e.g., downstream from the Narrows II Powerhouse).

Wheaton *et al.* (2004) further described how spawning habitat rehabilitation is segregated into three categories: (1) gravel augmentation; (2) hydraulic structure placement; and (3) spawning bed enhancement. Gravel augmentation (also known as gravel injection, infusion or replenishment) involves dumping clean spawning gravels into piles along the edges of a river (usually just downstream of a dam). For this approach to yield usable spawning habitat, practitioners must assume that high flows occur in the near future, that augmented gravels entrain during high flows, and that gravels do not fill mining holes or pools but instead deposit as bars or riffles. Hydraulic structure placement entails placement of large woody debris (LWD), boulder clusters, v-dams or similar structures to alter hydrodynamics in such a way that spawning gravels are deposited in the vicinity of the structures (Brookes *et al*. 1996 in Wheaton *et al.* 2004). The technique relies on an adequate supply of gravel from upstream and an active bedload transport regime to deliver it. Such structures may also be intended to provide refugia, cover and add habitat heterogeneity (Van-Zyll-De-Jong *et al*. 1997 in Wheaton *et al.* 2004). Spawning bed enhancement is the direct modification of the bed to provide immediate spawning habitat (e.g., riffle construction, bed ripping and riffle cleansing). Although bed enhancement may quickly provide usable spawning habitat, limited project lifespan may result without adequate consideration of geomorphic processes or regular gravel replenishment (Kondolf 2000b in Wheaton *et al.* 2004). In summary, spawning habitat rehabilitation projects are typically reach-scale restoration activities sometimes, but not necessarily, nested within a larger, long-term, basin-scale management plan (e.g., McBain and Trush 1997 in Wheaton *et al.* 2004).

Spawning habitat rehabilitation in the Englebright Dam Reach is expected to expand available spawning habitat primarily for spring-run Chinook salmon, because suitable flow and water temperature regimes already exist. A pilot gravel injection project was successfully completed in the Englebright Dam Reach during November 2007. Approximately 361 cubic yards of spawning gravels were injected below the Narrows II Powerhouse. Aerial redd surveys conducted during 2008 and snorkel surveys conducted during 2009 identified spring-run Chinook salmon utilizing small, localized pockets of gravel created by this pilot project. However, additional gravels, as well as hydraulic structure placement and spawning bed enhancement, are needed to fully rehabilitate this reach. Thus, the Englebright Dam Reach spawning habitat rehabilitation project is specifically comprised of shot-rock removal from Sinoro Bar, hydraulic structure placement and spawning bed enhancement of Sinoro Bar, gravel

injection downstream of Narrows II Powerhouse for recruitment to Sinoro Bar, and possible direct placement of gravel on Sinoro Bar itself (**Figure 2**).

**Figure 2. The Sinoro Bar site for spawning habitat rehabilitation.**

Spawning habitat rehabilitation in the Englebright Dam Reach of the lower Yuba River could provide additional spawning habitat to achieve the specific HET to accommodate an estimated net increase of 2,000 to 3,000 spring-run Chinook salmon spawning annually. A realistic approach to estimate the number of spring-run Chinook salmon that would be expected to utilize the habitat expansion resulting from the Englebright Dam Reach spawning habitat rehabilitation project is based on observations of actual SHIRA sites. The most data from SHIRA rehabilitation sites in the Central Valley is available from the Mokelumne River. For those SHIRA sites, 2005 redd surveys resulted in a calculation of 1 Chinook salmon redd per $17m^2$. For the Sinoro Bar project, an approximate area estimate of 40,500 $m^2$ could be expected to result in establishment of 2,382 spring-run Chinook salmon redds. Assuming 2 spring-run Chinook salmon adults per redd, the result would be 4,764 adult spring-run Chinook salmon.

Gravel augmentation in lower Deer Creek has been included as a potential component of the project. Spawning habitat rehabilitation in lower Deer Creek may have substantial benefit for steelhead. However, concerns persist regarding the efficacy of gravel augmentation in Deer Creek due to: (1) flow patterns associated with releases from Lake Wildwood; (2) the presence of a significant falls located approximately 500 feet upstream of the mouth of Deer Creek which

is likely impassable during drier years, although steelhead have been found above the falls during wetter years with high runoff (CDFG 1991); and, particularly (3) extant water temperatures during the spring-run Chinook salmon spawning period.

## Side Channel, Floodplain, and Riparian Habitat Restoration

As previously mentioned, several factors continue to influence juvenile spring-run Chinook salmon and steelhead rearing habitat suitability: (1) including sparse and restricted amounts of riparian vegetation and associated instream object and overhanging object cover; (2) limited aquatic habitat complexity and diversity; and (3) altered natural river function and morphology in the lower Yuba River. SRA habitat generally occurs in the lower Yuba River as scattered, short strips, with the most extensive and continuous segments of SRA habitat occurring along bars where recent channel migrations or avulsions have cut new channels through stands of riparian vegetation.

The juvenile salmonid rearing habitat expansion actions directly address the overall goal of the HEA, which is to expand the amount of habitat with the physical characteristics necessary to support spawning, rearing and adult holding of spring-run Chinook salmon and steelhead. Moreover, these actions are consistent with several key near-term and long-term habitat restoration actions identified in the Draft Recovery Plan for the lower Yuba River, including: (1) the creation and restoration of side-channel habitats to increase the quantity and quality of off-channel rearing (and spawning) areas; (2) improvement of riparian habitats for juvenile salmonid rearing; and (3) implementation of projects to increase floodplain habitat availability to improve habitat conditions for juvenile rearing.

Several ongoing activities addressing habitat enhancement opportunities in the lower Yuba River have recently been funded by the RMT, Anadromous Fish Restoration Program (AFRP), and PG&E. These activities include conducting studies and obtaining fluvial/geomorphological information necessary to guide habitat enhancement actions, and also include the conduct of pilot habitat enhancement projects in the lower Yuba River. The RMT M&E Program has completed or soon will have available invaluable information to guide specific spring-run Chinook salmon (and steelhead) juvenile rearing habitat enhancement actions. In addition to habitat utilization, specific physical habitat capabilities, which will be generally available (including to the HEA Steering Committee), to guide habitat enhancement actions include:

- Morphological Unit & Mesohabitat Classification
- Substrate and Cover Classification and Mapping
- Topographic Mapping
- Development of a Digital Elevation Model of the entire 24 miles of the lower Yuba River
- Development of a 2-D Hydraulic Model

In addition, SYRCL has been funded by the AFRP to conduct a pilot project, taking advantage of a conservation easement on Western Aggregates land, directed towards enhancing juvenile salmonid rearing habitat. The pilot project is considering creation of new functional floodplain habitat, off-channel rearing habitat (backwaters and side-channels), installation of large wood structure and enhancement of riparian vegetation. At present, a pre-project assessment is being conducted to inform opportunities for juvenile salmonid habitat enhancements in a 3.5-mile study reach from Parks Bar to Hammon Bar on the lower Yuba River. The pre-project assessment is addressing the geomorphic, hydrologic, and biotic factors influencing: (1) available floodplain habitat; (2) creation and maintenance of marginal and off-channel rearing habitat; and (3) riparian recruitment, growth, and survival in the project area. Current work includes a public outreach component to inform nearby landowners, concerned stakeholders, and watershed groups about the proposed pilot project. Information obtained through this pilot project also will inform future habitat enhancement actions in the lower Yuba River.

Members of the RMT conducted a field tour of the lower Yuba River on October 7, 2009, and among other activities reviewed and further discussed potential spring-run Chinook salmon (and steelhead) juvenile rearing habitat expansion projects. Some of the RMT representatives believe that the most beneficial and cost-effective type of juvenile rearing habitat expansion projects, and those that would yield the most immediate benefits, would be the creation of new side-channel habitats associated with existing stands of riparian vegetation not hydraulically connected to the river channel. Specifically, the benefit of new side-channel habitats would: (1) increase and maintain existing riparian vegetation; (2) provide instream object and overhanging object cover; (3) provide new SRA, and associated allochthonous food sources for rearing juveniles; (4) increase aquatic habitat complexity and diversity; (5) provide habitats more consistent with those previously available in the upper watershed; and (6) provide predator escape cover, and overall increased survival of juvenile spring-run Chinook salmon and steelhead.

On October 13, 2009 a small group of RMT members met to further identify and refine potential juvenile salmonid rearing habitat expansion actions for the lower Yuba River. Following a thorough discussion regarding project effectiveness within a fluvial geomorphological perspective, this stakeholder group identified nine habitat enhancement actions/locations to provide rearing habitat for juvenile spring-run Chinook salmon and steelhead. Essentially, the group reviewed locations along the lower Yuba River where residual riparian vegetation indicated that the river channel had previously existed. In several of these locations, the hydraulically disconnected river channel could be re-connected fairly easily, thus developing additional secondary (side-channel) habitat. Based on work conducted in the lower Yuba River by Professor Greg Pasternack (UC Davis) and the RMT, the group determined that these side-channel habitat locations are viable for re-construction.

From upstream to downstream in the lower Yuba River, they have been identified as follows:

## Upstream of Daguerre Point Dam

The lower Yuba River extends approximately 12.6 miles from Englebright Dam to Daguerre Point Dam. The following juvenile salmonid rearing habitat enhancement action sites are located within this section of the lower Yuba River.

**Site 1** (**Figure 3**) "Upper Gilt Edge" – Enhance the structural complexity of the left bank of the main river channel. Line the left bank of the main channel with boulder/wood structures, and enhance an ephemeral backwater with boulder/wood structures to maintain aquatic habitat.

**Site 2** (**Figure 4**) "First Island" – Create a side channel in an existing swale within a stand of relatively dense riparian vegetation. Enhance the structural complexity of the left bank of the main river channel by placement of large wood material. Approximate length 1,500 ft, potential area 30,000 $ft^2$ (0.7 ac at 20 ft width, 60,000 $ft^2$ (1.4 ac) at 40 ft width.

**Site 3** (**Figure 5**) "North Silica Bar" (bar opposite of Silica Bar side channel) – Create a side channel in an existing swale within a stand of relatively dense riparian vegetation which presently includes willows and cottonwoods. Approximate length 4,600 ft, potential area 92,000 $ft^2$ (2.1 ac at 20 ft width, 189,000 $ft^2$ (4.3 ac) at 40 ft width.

**Site 4** (included in Figure 5) "Silica Bar" – Create a side channel in an existing swale within a stand of diverse, mature, native riparian vegetation. Approximate length 2,000 ft, potential area 40,000 $ft^2$ (0.9 ac at 20 ft width, 80,000 $ft^2$ (1.9 ac) at 40 ft width.

**Site 5** (**Figure 6**) "Hammon Bar" – Create a side-channel, within a stand of riparian vegetation, extending from the bar on the southern bank of the main-channel into the current backwater area. Boulder structures for hydraulic maintenance may be placed at the inflow section. At the outflow section, wood/boulder structures may be placed, and riparian vegetation may be planted. Approximate length 1,250 ft, potential area 25,000 $ft^2$ (0.6 ac at 20 ft width, 50,000 $ft^2$ (1.1 ac) at 40 ft width.

**Site 6** (**Figure 7**) "South Bar above Daguerre Point Dam" – Create a side channel, within a stand of riparian vegetation, along the toe of the training wall, extending from the upper portion of the site to the existing downstream backwater area. Boulders for hydraulic maintenance may be placed at the inflow. Approximate length 2,400 ft, potential area 48,000 $ft^2$ (1.1 ac at 20 ft width, 96,000 $ft^2$ (2.2 ac) at 40 ft width.

## Downstream of Daguerre Point Dam

The lower Yuba River extends approximately 11.4 miles from Daguerre Point Dam to the confluence with the lower Feather River. The following juvenile salmonid rearing habitat enhancement action sites are located within this section of the lower Yuba River.

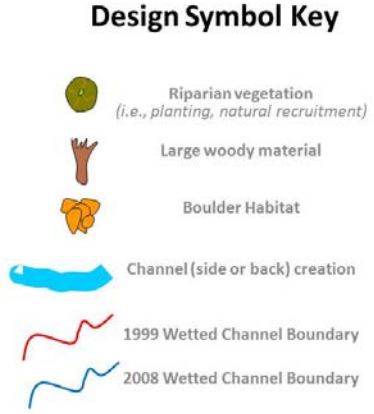
**Site 7** (**Figure 8**) "Waterway 13" – Create a side-channel, within a stand of riparian vegetation, extending from the main-channel into the current backwater area. Boulder structures for hydraulic maintenance may be placed at the inflow section. This site would be expected to receive flow augmentation from the Yuba Goldfields return flow. Approximate length 2,800 ft, potential area 56,000 $ft^2$ (1.3 ac at 20 ft width, 112,000 $ft^2$ (2.6 ac) at 40 ft width.

**Site 8** (**Figure 9**) "Narrow Bar" – Create a side-channel north of the main channel following a historic channel path. Existing riparian vegetation would border the created side-channel. Boulders for hydraulic maintenance may be placed at the inflow. Approximate length 2,900 ft, potential area 58,000 $ft^2$ (1.3 ac at 20 ft width, 116,000 $ft^2$ (2.7 ac) at 40 ft width.

**Site 9** (**Figure 10**) "Goldfields Terminus" – Create a side-channel, within a stand of riparian vegetation, extending into a current backwater habitat located at the downstream corner of the Goldfields. Boulder structures for hydraulic maintenance may be placed at the inflow section. Approximate length 5,000 ft, potential area 100,000 $ft^2$ (2.3 ac at 20 ft width, 200,000 $ft^2$ (4.6 ac) at 40 ft width.

Figures 3 – 10 identify the locations of the potential sites for habitat enhancement. Design plans would be informed by the information and processes listed above. The precise location of side-channels as well as the placement of structural elements and riparian plantings would be informed by a variety of analyses including hydraulic modeling. As evidenced by existing riparian vegetation or topography in Figures 3 - 10, many of these potential side channels follow previous alignments of the river, or were side channels. Additional geomorphic analysis will be necessary to fully understand the processes that originally formed these channels and subsequently moved the river to a different location. However, these features were selected based on the premise that: (a) side channels can be re-established relatively easily using moderate terra-forming, boulder placement, and other techniques; and (b) that the features will have more than a short-term persistence in the river once constructed.

The Design Symbol Key (below) is utilized in the following figures.



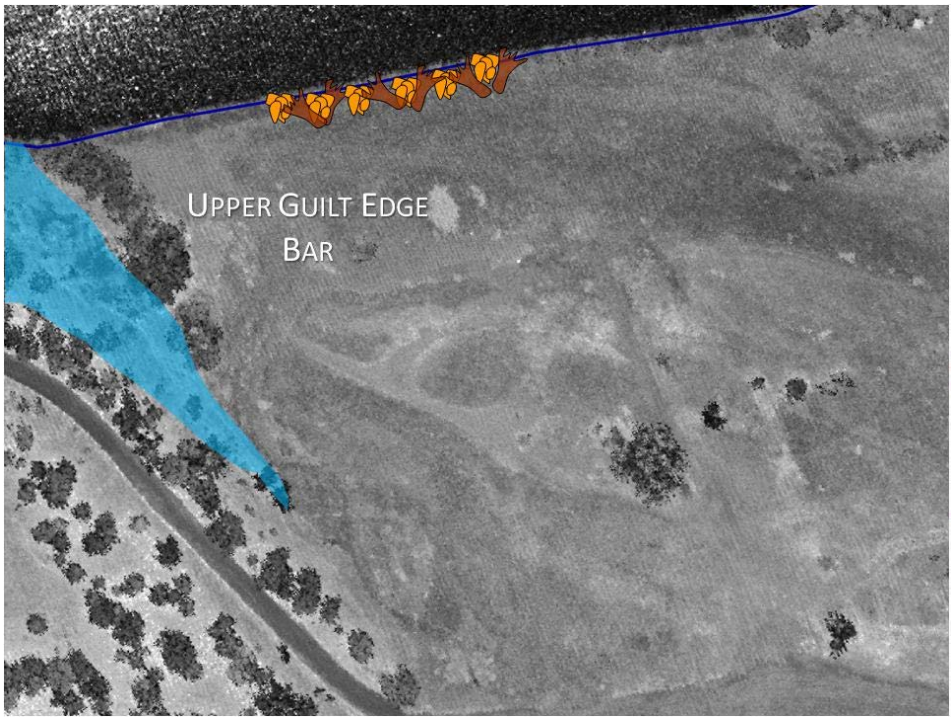



**Figure 3. The Upper Guilt Edge Bar site for juvenile rearing habitat enhancement.**

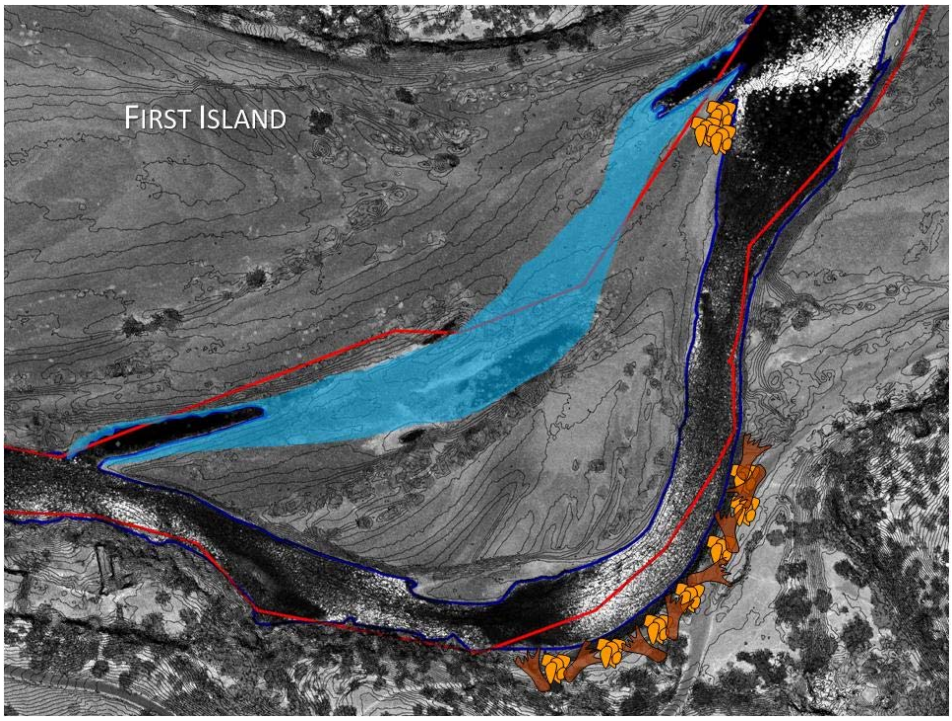



**Figure 4. The First Island site for juvenile rearing habitat enhancement.**

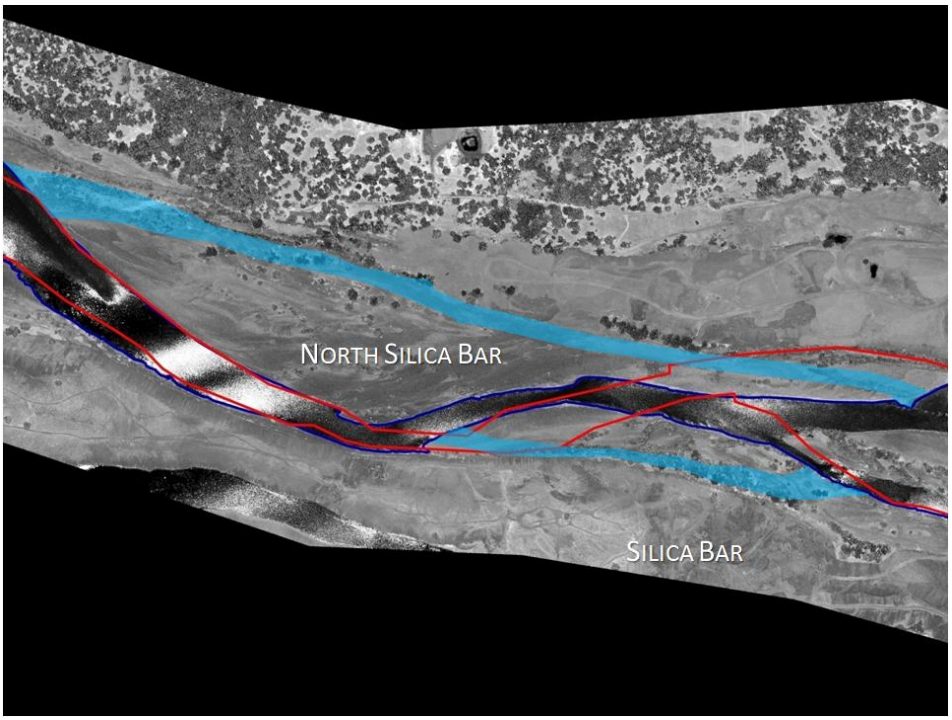



**Figure 5. The North Silica Bar and Silica Bar sites for juvenile rearing habitat enhancement.**

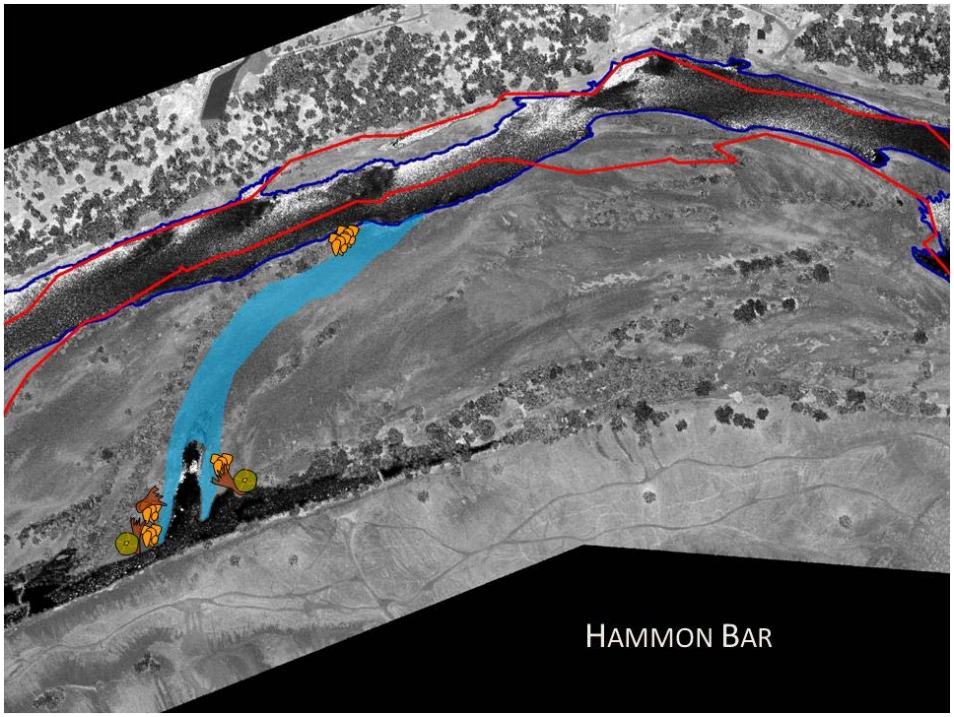



**Figure 6. The Hammon Bar site for juvenile rearing habitat enhancement.**

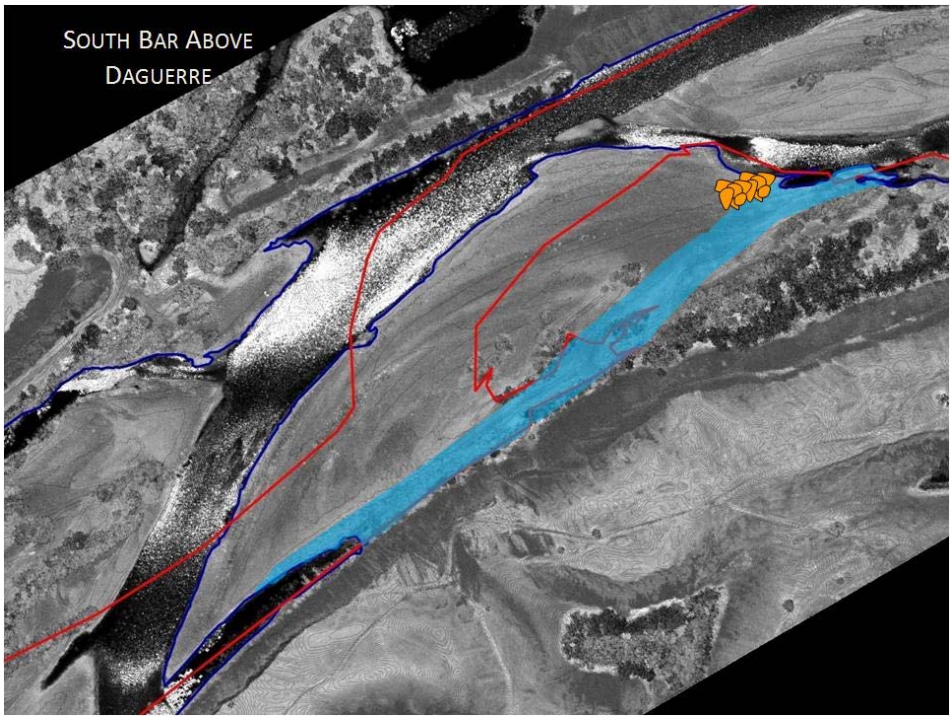



**Figure 7. The South Bar above Daguerre Point Dam site for juvenile rearing enhancement.**

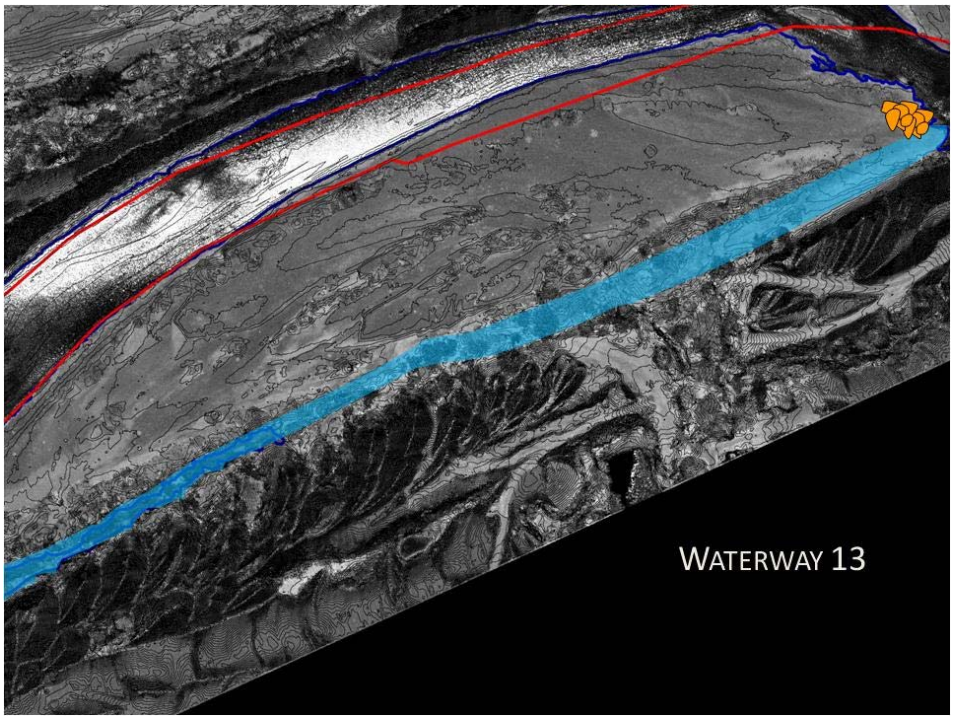



**Figure 8. The Waterway 13 site for juvenile rearing habitat enhancement.**

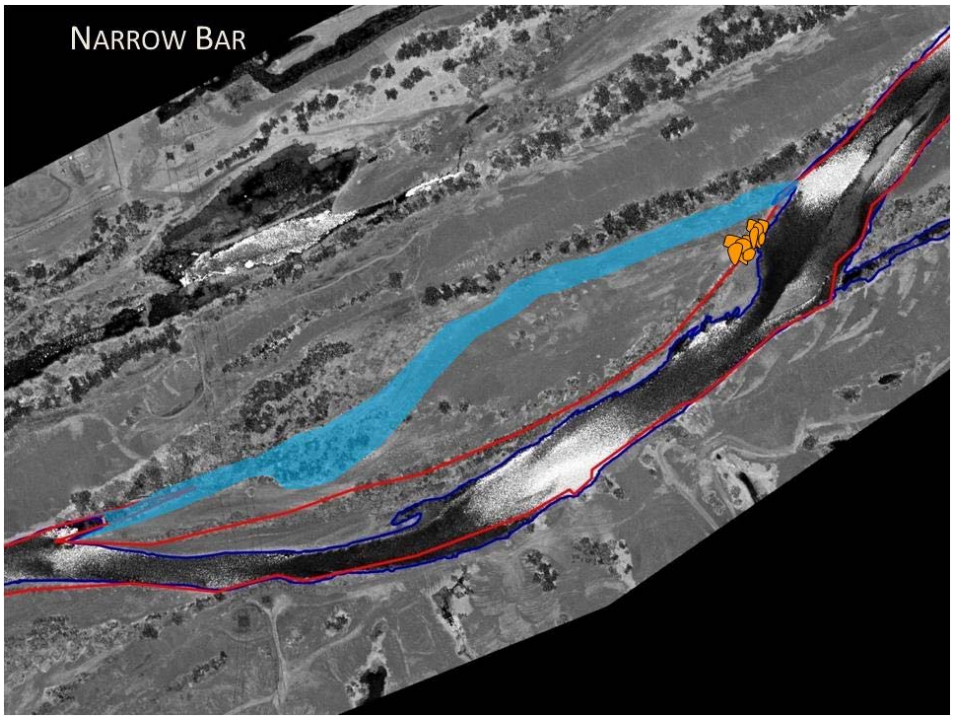



**Figure 9. The Narrow Bar site for juvenile rearing habitat enhancement.**

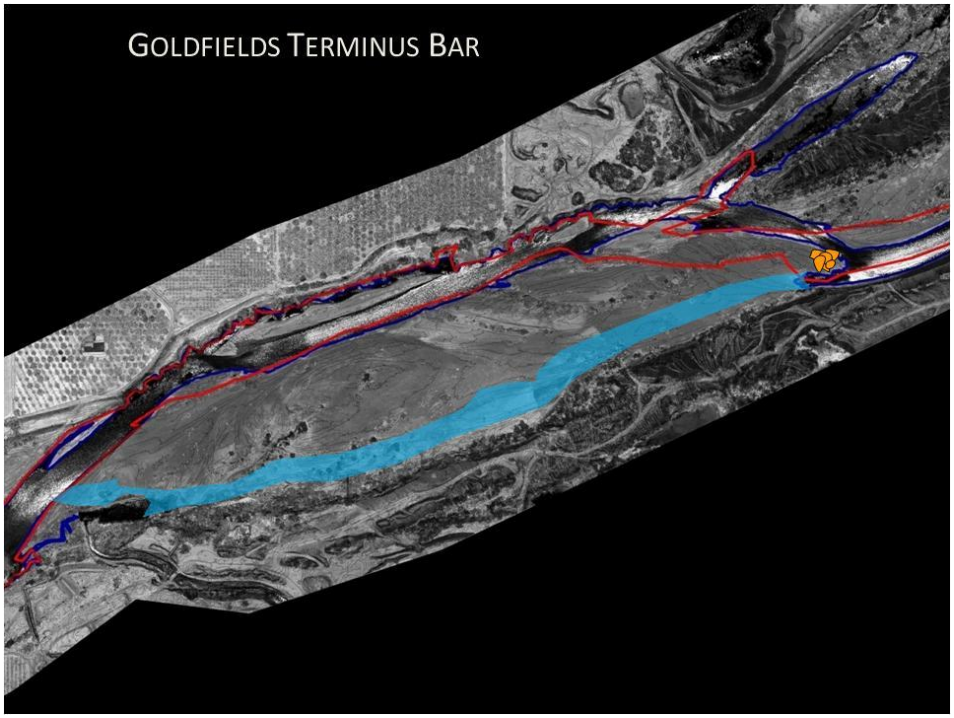



**Figure 10. The Goldfields Terminus Bar site for juvenile rearing habitat enhancement.**

## Segregation Weir

The intent of the segregation weir component is to achieve "…*favorable spatial separation from other populations or runs to maintain genetic diversity by minimizing interbreeding…*" A priority within the HEA is the segregation of habitat for spring-run and fall-run Chinook salmon. In the Central Valley, introgression of fall- and spring-run Chinook salmon has been identified as a potential factor limiting spring-run Chinook salmon. In many cases, this is due to the concurrent spawning of hatchery-produced fall-run Chinook salmon in areas where spawning of spring-run Chinook salmon occurs.

Unlike many rivers in the Central Valley, there is no hatchery on the lower Yuba River. However, some straying does occur in the lower Yuba River, most likely from the Feather River Hatchery. However, straying of fish into the lower Yuba River can be addressed by a number of actions including replacing off-site releases with volitional releases from the hatchery, allowing all fish that attempt to return to the hatchery to do so, and reducing the amount of fish released (see CDFG and NMFS (2001), for a review of hatchery issues). Currently, best management practices and a hatchery genetics management plan continue to be developed and implemented at the Feather River Hatchery.

Further, to address the problem of introgression of fall- and spring-run Chinook salmon, the HEA criterion indicate that projects that encourage the separation of fall- and spring-run Chinook salmon will be considered favorable. Separation may be achieved either through physical barriers or through the development of habitat conditions that favor spring-run Chinook salmon over fall-run Chinook salmon. Clearly, the intent is to achieve separation of fall-run and spring-run Chinook salmon to minimize/avoid genetic introgression.

The biologic premise behind the concept of "separation" is the intent to achieve reproductive isolation. Reproductive isolation has a spatial and/or temporal component that, in a natural system, can be accomplished through behavioral manifestation achieving spatial and/or temporal segregation. In the lower Yuba River, to some extent spatial and temporal segregation of Chinook salmon spawning presently occurs. Previously conducted reconnaissance-level redd surveys, carcass surveys, and the more intensive 2008 pilot redd survey demonstrate that the majority of redds constructed during September to early October (phenotypically consistent with spring-run Chinook salmon spawning timing) were observed in the uppermost portion of the survey area (i.e., upstream of the Highway 20 Bridge). Preliminary data obtained from early season redd surveys conducted from August 31 through October 1, 2009 demonstrate that of the total 714 redds constructed during this period throughout the lower Yuba River, 520 (73%) were constructed upstream of the Highway 20 Bridge. By contrast, redds constructed later in the season (phenotypically consistent with fall-run Chinook salmon spawning timing) were primarily observed further downstream in the lower Yuba River. Preliminary 2009 data demonstrate of the

1,598 redds constructed since October 1 through October 29, 2009, 952 (60%) were constructed downstream of the Highway 20 Bridge.

Seasonal flow releases and suitable spring-run Chinook salmon water temperatures are currently being provided by implementation of the Yuba Accord, which enhances the spawning of phenotypically characterized spring-run Chinook salmon. Additional monitoring (acoustic tracking, spawning surveys, genetic analysis) is ongoing, and will provide additional information regarding the current extent of reproductive isolation between spring-run and fall-run Chinook salmon in the lower Yuba River. The need for, benefits of, and specific operational considerations for the segregation weir component of the project are presently uncertain, and can be more completely evaluated following results from ongoing studies by the Yuba Accord RMT. A genetic analysis of phenotypic spring-run Chinook salmon collected in the lower Yuba River is in progress. The results of this study will help identify the amount of introgression among spring-run and fall-run Chinook salmon, and source populations for phenotypic spring-run Chinook salmon that currently exist in the lower Yuba River. Ongoing monitoring conducted as part of the Yuba Accord M&E Program will provide additional information regarding specific timing and specific locations of adult immigration, holding, and spawning of Chinook salmon in the lower Yuba River. This additional information will be useful to evaluate the need for, and potential location of a segregation weir in the future. In addition, evaluation of the technical feasibility and full costs associated with implementation of a segregation weir in the lower Yuba River remains to be conducted. At a minimum, careful consideration of the feasibility and full costs of construction of a hard-mounted fish barrier (including in-river construction techniques and impacts), the costs of developing and securing access for construction and operations, the challenges of operations and cleaning, and the risk and potential for damage by high or flood flows will need to be undertaken prior to a final decision on this potential project.

The segregation weir is not supported at this time.

## Daguerre Point Dam Passage Improvement

Upstream passage at the Corps Daguerre Point Dam can be impeded for migrating adult spring-run Chinook salmon and steelhead due to the inadequacies of the fish ladders. Adult salmonid passage is impeded when rain or snowmelt runoff produces high flow conditions at the dam, which coincides with flow conditions under which spring-run Chinook salmon and steelhead generally migrate upstream to their spawning areas. The Corps' policy is to close the ladders when water elevation reaches 130 feet, and to keep them closed until the water recedes to an elevation of 127 feet. Because spring-run Chinook salmon and steelhead upstream migration occurs during the potentially high-flow periods during winter and spring, this policy can affect their upstream migration. Throughout winter and spring when flows are high, adult spring-run Chinook salmon and steelhead can experience difficulty in finding the entrance to the ladders because of the relatively low percentage of attraction flows exiting the ladders compared to the

massive sheet-flow coming over the rest of the dam. The angle of the orifices and proximity to the plunge pool also increase the difficulty for fish to find the entrances to the ladders. Other design deficiencies which have been identified include periodic obstruction of the ladders by woody material, operating criteria that require closure of the ladders at high flows, and the proximity and orientation of the ladder entrances to the spillway (CDFG 1991; USFWS 1994 in NMFS 2007).

Upstream passage at the Corps Daguerre Point Dam can also be impeded when sediment builds up near the upstream exit of the fish ladders. Geofluvial action has, in the past, caused gravel to build up on the upstream side of the dam where it can impede flows into the ladders, thereby reducing the ability of fish to climb the ladders and reducing the attraction flow exiting the base of the ladders. In addition, the gravel bars have built up to the point where they reduce access to the main channel for fish that have exited at the top of the ladders and are attempting to continue their upstream migration. The Corps has initiated a long-term sediment management program to address this problem, and it is expected that this issue will be alleviated through continued diligent implementation of this program.

Adult Chinook salmon have been observed congregating in the plunge pool below the dam and leaping at the face of the dam, indicating that migrating adults may not readily find the entrances to the fish ladders. A simple time delay is not the only consequence of spring-run Chinook salmon being unable to pass Daguerre Point Dam. When adult Chinook salmon enter fresh water they cease eating and must rely solely on the finite supply of energy which they have stored in their bodies to last them through their entire migration, holding, and spawning activities. In their efforts to pass Daguerre Point Dam, particularly if these efforts continue for several days or even weeks, they consume a greater amount of these energy stores than if there had been no obstacle in their path. This may leave the fish in a weakened state before spawning which may subject them to a greater chance of disease, especially if they have to hold over the summer prior to spawning (e.g., spring-run Chinook salmon). Other biological consequences of blockage or passage delay include changes in spawning distribution (Hallock 1987), increased adult pre-spawning mortality (Reclamation 1985 in NMFS 2007), and decreased egg viability (Vogel *et al.* 1988), all of which may result in the reduction in abundance and productivity of this species.

Juvenile salmonids can also be adversely affected by Daguerre Point Dam on their downstream migration. Juveniles can experience injury or direct mortality by being carried over the face of the dam by sheet flow and encountering the dam face or the downstream base of the dam. Also, there is an elevated risk of predation created when juveniles plunge over the dam into the pool below. The large plunge pool at the base of the dam creates an area for predatory fish which may seasonally congregate below Daguerre Point Dam. The deep pool provides ambush habitat for predators in an area where juvenile salmonids can be disoriented or injured as they plunge over the face of the dam into the turbulent waters at the base, making them vulnerable to

predation. High levels of predation over long periods of time can reduce juvenile numbers and weaken their contribution to year class strength and recruitment.

The potential to improve both adult upstream and juvenile downstream passage at Daguerre Point Dam has been the subject of previous studies, including: (1) Daguerre Point Dam Fish Passage Improvement Project Alternative Concepts Evaluation (DWR and Corps 2003 in NMFS 2007); (2) Daguerre Point Dam Fish Passage Improvement Project 2002 Fisheries Studies – Analysis of Potential Benefits to Salmon and Steelhead from Improved Fish Passage at Daguerre Point Dam (DWR and Corps 2003a in NMFS 2007); and (3) Daguerre Point Dam Fish Passage Improvement 2002 Water Resources Studies (DWR and Corps 2003b in NMFS 2007). In November 2007 NMFS issued a Biological Opinion (NMFS 2007) on the operation of Corps facilities on the Yuba River, including Daguerre Point Dam and passage-related issues. Passage at Daguerre Point Dam is the subject of ongoing considerations. Although much evaluation and analysis has already been completed, a final preferred alternative has not yet been identified to alleviate passage impediment issues at Daguerre Point Dam.

# SELECTION AND APPROVAL CRITERIA CONSIDERATIONS

## CONTRIBUTION TO ACHIEVING THE HABITAT EXPANSION THRESHOLD

*As previously mentioned, the specific Habitat Expansion Threshold (HET) is to expand spawning, rearing and adult habitat sufficiently to accommodate an estimated net increase of 2,000 to 3,000 spring-run Chinook salmon for spawning in the Sacramento River Basin. The Habitat Expansion Threshold is focused on spring-run Chinook salmon as the priority species, as expansion of habitat for spring-run Chinook salmon typically accommodates steelhead as well.*

Preliminary estimates indicate that spawning habitat rehabilitation in the Englebright Dam Reach of the lower Yuba River could provide additional spawning habitat for 4,764 spring-run Chinook salmon, and thereby achieve the specific HET to accommodate an estimated net increase of 2,000 to 3,000 spring-run Chinook salmon spawning annually. The benefit of new side-channel habitats would: (1) increase and maintain existing riparian vegetation; (2) provide instream object and overhanging object cover; (3) provide new SRA, and associated allochthonous food sources for rearing juveniles; (4) increase aquatic habitat complexity and diversity; (5) provide habitats more consistent with those previously available in the upper watershed; and (6) provide predator escape cover, and overall increased survival of juvenile spring-run Chinook salmon and steelhead – all of which would thereby contribute to increased annual spawning run abundance. Based on preliminary estimates of area (scaled from Figures 4 – 11 herein), additional aquatic rearing habitat could be 10 to 21 acres; additional riparian habitat could be an additional 10 to 21 acres.

As previously mentioned, a segregation weir does not, unto itself, expand habitat and directly contribute to achieving the goals of the HET. Rather, the stated intent is to accomplish geographic distinction (and reproductive isolation) and thereby reduce the potential for genetic introgression between fall-run and spring-run Chinook salmon. Similarly, although improved fish passage at the Corps Daguerre Point Dam would help to facilitate access to available upstream habitat, it would not expand the amount of habitat with the physical characteristics necessary to support spawning, rearing and adult holding of spring-run Chinook salmon and steelhead.

## MOST COST-EFFECTIVE COMPARED TO OTHER POTENTIAL HABITAT EXPANSION ACTIONS

*For each Viable Action, a rough estimate of its cost and contribution to the HET will be determined. Each Viable Action then will be ranked in terms of its cost effectiveness (i.e., the cost of the action versus its contribution to the HET). Refer to the discussion of favorable cost effectiveness in Evaluation Criterion (d).*

Based upon the economic feasibility (below) it is possible that the proposed habitat enhancement actions in the lower Yuba River can be implemented within extant funding limitations, and would achieve or exceed the specific HET goal of establishing a self-sustaining, viable population, representing a net increase of 2,000 to 3,000 spring-run Chinook salmon spawning annually in the Central Valley. Although uncertainty remains regarding the feasibility and cost, particularly associated with the segregation weir, and the consideration that Daguerre Point Dam fish passage improvements may be required to be implemented through other processes, the Englebright Dam Reach spawning habitat rehabilitation component would be extremely cost-effective, and the juvenile salmonid rearing habitat enhancement actions would have synergistic benefit and augment resulting habitat expansion through enhanced spring-run Chinook salmon and steelhead juvenile production.

## FEASIBILITY (ACTION[S] CAN REASONABLY BE ACCOMPLISHED)

*As stated in Evaluation Criterion (a), actions/projects must have a high likelihood of success (i.e., they must be highly feasible). The term "feasibility" is being interpreted broadly to include the concepts described for four Evaluation Criteria: (a) technical feasibility, (d) economic feasibility, (i) favorable political and local support, and (l) consistency with other resource uses.*

The feasibility varies among the suite of actions being considered by the HEA Steering Committee.

The Englebright Dam Reach spawning habitat rehabilitation component is highly feasible, based upon a 5-year (2003-2008) comprehensive investigation conducted to ascertain the linkages between hydrology, geomorphology, and ecology (Pasternack 2009), and a 2007 pilot gravel injection study. Pasternack (2009) highly recommended that such a project be designed using the Spawning Habitat Integrated Rehabilitation Approach (SHIRA) that is in use on the Feather, American, Trinity, and Mokelumne Rivers. For details, see the website at http://shira.lawr.ucdavis.edu. Using SHIRA would ensure that a project of this magnitude would immediately yield spawning habitat, as has been documented thoroughly on the Mokelumne and Trinity Rivers. We have not prepared a cost estimate for the Englebright Dam Reach spawning habitat rehabilitation action. However, in response to the HEA questionnaire, the stated cost of this action was approximately $3 million, although it is uncertain whether this stated cost includes all project-related requirements.

Prior to the RMT's field tour of potential juvenile salmonid rearing habitat enhancement projects and further identification and refinement of specific actions, the response to the HEA questionnaire stated that the cost of this action was $2 million, although it is uncertain whether this stated cost includes all project-related requirements. We have not prepared a cost estimate for the juvenile salmonid habitat enhancement actions. However, review of Appendix E in the Draft Recovery Plan suggests that "channel restoration" pertinent to Central Valley rivers ranges in cost from $1.2 million to $8.7 million per mile, and USFWS reports that for AFRP habitat enhancement/development actions, cost estimates of $1.0 to $1.5 million per mile were derived. The HEA Steering Committee would likely need to develop their own cost estimates.

The suite of actions considered by the HEA Steering Committee also may include a segregation weir located approximately 6 miles below Englebright Dam to provide spawning segregation of spring-run Chinook salmon from fall-run Chinook salmon. The need for, benefits of, and specific operational considerations for the segregation weir component of the project are presently uncertain, and can be more completely evaluated following results from ongoing studies by the Yuba Accord RMT involving tagging, tracking, redd mapping and genetic analysis. Although resistance board segregation weirs are versatile and have been used in other locations, evaluation of the technical feasibility and full costs associated with implementation in the lower Yuba River have not been conducted. We have not prepared a cost estimate for the segregation weir action. However, in response to the HEA questionnaire, it was suggested that based on a preliminary, reconnaissance-level review, a resistance board weir would cost approximately $220,000 for installation and $52,000 annually for weir operation and monitoring, although it is likely that this stated cost does not include all project-related requirements. At a minimum, careful consideration of the full costs of construction of a hard-mounted fish barrier, the costs of developing and securing access for construction and operations, the cost associated with operations and cleaning, and the costs associated with maintenance and the potential for damage

by high or flood flows will need to be undertaken prior to a final decision on this potential project.

Potential alternatives associated with fish passage improvements at the Corps Daguerre Point Dam continue to be part of ongoing investigations. According to the NMFS 2007 Biological Opinion (BO), the Corps shall develop and implement a plan to improve fish passage for adult and juvenile spring-run Chinook salmon, steelhead and green sturgeon at Daguerre Point Dam. Moreover, the NMFS BO requires that the Corps shall complete the feasibility study and PED phases of the ongoing fish passage improvement project, as described in the Corps biological assessment for the proposed project, within five years of the issuance of the BO. It further requires that the Corps shall commence implementation of the preferred alternative to improve fish passage for adult and juvenile spring-run Chinook salmon, steelhead and green sturgeon at Daguerre Point Dam, developed through the feasibility study and PED process, within ten years of the issuance of the BO. Therefore, it may be appropriate to assume that associated costs would be the Corps responsibility, and not necessarily be an appropriate consideration pursuant to the HEA eligibility criteria.

## TIMING (EXPECTED TO BE IMPLEMENTED WITHIN A REASONABLE PERIOD OF TIME)

*As noted in Evaluation Criterion (h), factors important to the success of a project include not only the length of time to implement the project but also the length of time to realize benefits. Thus, the HEP will favor "shovel-ready" projects that can be implemented in a reasonable period of time (e.g., less than approximately 5 years). The more favorable projects will be those that need minimal additional public process, particularly related to permitting, zoning, or land use issues. In addition, projects that benefit spring-run Chinook within a relatively short period of time (e.g., approximately 10 years or less) will be favored.*

The Englebright Dam Reach spawning habitat rehabilitation project is essentially "shovel ready". A 5-year (2003-2008) comprehensive investigation has been conducted to ascertain the linkages between hydrology, geomorphology, and ecology (Pasternack 2009), and a 2007 pilot gravel injection study has been implemented. Located in a remote rural area, this project requires minimal additional public process, particularly related to permitting, zoning, or land use issues. The project could be implemented once final design, plans and specifications are completed, and appropriate permits are obtained (potentially less than one year). By using the SHIRA approach that is in use on the Feather, American, Trinity, and Mokelumne rivers, a project of this magnitude would immediately yield spawning habitat, as has been thoroughly documented on the Mokelumne and Trinity rivers.

It is anticipated that the proposed juvenile salmonid rearing habitat enhancement actions would be designed, access and permits obtained, and selected actions implemented consistent with the approval and implementation schedule established for the HEA implementation process. Given the tools in development and work currently underway (e.g., mapping of entire lower Yuba, 2D hydraulic model of the lower Yuba River, pilot restoration project design), it seems likely that a preliminary design and permitting analysis could be completed within 1 year. Permitting, landowner access and other issues could be resolved within 1 to 2 years, depending on complexities. Construction could be accomplished in one to two seasons.

As previously discussed, the need for, benefits of, and specific operational considerations for the segregation weir component of the project are presently uncertain. Evaluation of the technical feasibility associated with implementation in the lower Yuba River has not been conducted. It is uncertain when evaluation of the infrastructure integrity and operations and management practices, access logistics, a feasibility study, and obtaining appropriate permits would occur.

The NMFS 2007 BO requires that the Corps shall complete the feasibility study and PED phases of the ongoing Daguerre Point Dam fish passage improvement project within five years of the issuance of the BO. It further requires that the Corps shall commence implementation of the preferred alternative to improve fish passage for adult and juvenile spring-run Chinook salmon, steelhead and green sturgeon at Daguerre Point Dam, developed through the feasibility study and PED process, within ten years of the issuance of the BO. However, in consideration that the NMFS 2007 BO is the subject of a legal challenge pending in the United States District Court for the Eastern District of California, specific timing is presently uncertain.

## RELATIONSHIP TO OTHER PARTIES

> *Actions identified in other venues are eligible for consideration provided that what is implemented under the HEA results in an expansion of habitat over any existing requirements and commitments. As stated in Evaluation Criterion (n), projects required as part of other proceedings… will not be favored and may be considered ineligible.*

Although the cessation of spawning gravel recruitment from areas upstream of the Corps Englebright Dam may be directly attributable to the presence of the dam, some of the shot-rock on Sinoro Bar results from high flows and landslides, and the geomorphic structure also has been influenced by local instream gravel mining. Research conducted by Professor Greg Pasternack (UC Davis) provides substantial evidence that the downstream section of the Englebright Dam Reach (including Sinoro Bar) is primarily impacted by historic hydraulic gold mining and modern mechanized placer mining conducted since 1960 (Pasternack 2009). Thus, the Englebright Dam Reach spawning habitat rehabilitation project addresses physical habitat conditions distinct from those directly associated with construction of the Corps Englebright

Dam. The Englebright Dam Reach spawning habitat rehabilitation project proposed for HEA consideration includes shot-rock removal, localized grading and contouring, placement of hydraulic roughness elements, and initial gravel placement.

Although the Corps is required to implement a long-term gravel augmentation program by the NMFS 2007 BO, such a program would provide minimal benefits to spring-run Chinook salmon and steelhead until the channel is rehabilitated from instream gravel mining and deposition of shot-rock. After initial spawning habitat rehabilitation and the provision of gravel associated with the Englebright Dam Reach spawning habitat rehabilitation project, it is suggested that ongoing gravel supply would then be maintained as per requirements of the Corps in the NMFS 2007 BO, or whatever requirements emanate from the legal challenge pending in the United States District court for the Eastern District of California. That ongoing process injects additional uncertainty regarding the timing of the Corps participation in this project. It has been estimated that ongoing annual maintenance of the spawning habitat could be accomplished through the injection of approximately 10,000 cubic yards of gravel per year (Pasternack 2009).

The juvenile salmonid rearing habitat enhancement project is not required under other venues, and would be appropriate for funding under the HEA. As stated in SYRCL's response to the questionnaire for this project, funding partners could include the Corps, Western Aggregates, PG&E, BLM, USFWS AFRP and project partners could include the Corps and SYRCL. It is presently undetermined what parties would be responsible for continued maintenance of the juvenile salmonid rearing habitat enhancement project. However, considering that construction of Englebright Dam by the Corps has resulted in the reduced functionality of juvenile salmonid rearing habitat in the lower Yuba River, it may be appropriate to consider the Corps as the primary responsible party for continued maintenance. Although the Corps is required to implement by 2012 a program of large wood supply to the lower Yuba River by the NMFS 2007 BO (legal challenge pending), that requirement does not include the proposed juvenile salmonid rearing habitat enhancement project.

The Yuba Accord RMT subcommittee does not specifically recommend the segregation weir project for the lower Yuba River at this time. However, as the HEA Steering Committee continues to consider numerous specific projects, it is noted that, as stated in SYRCL's response to the questionnaire for this project, funding partners could include PG&E (per the Narrows Mitigation Fund) and the USFWS AFRP, and project partners could include the Corps.

Potential alternatives associated with fish passage improvements at Daguerre Point Dam continue to be part of ongoing investigations. According to the NMFS 2007 BO, the Corps shall develop and implement a plan to improve fish passage for adult and juvenile spring-run Chinook salmon, steelhead and green sturgeon at Daguerre Point Dam. Moreover, the NMFS BO requires that the Corps shall complete the feasibility study and PED phases of the ongoing fish passage

improvement project, as described in the Corps biological assessment for the proposed project, within five years of the issuance of the biological opinion. It further requires that the Corps shall commence implementation of the preferred alternative to improve fish passage for adult and juvenile spring-run Chinook salmon, steelhead and green sturgeon at Daguerre Point Dam, developed through the feasibility study and PED process, within ten years of the issuance of the biological opinion. Although the NMFS 2007 BO is the subject of a legal challenge pending in the United States District Court for the Eastern District of California, it is anticipated that fish passage improvements at Daguerre Point Dam will remain the Corps' responsibility.

## SUPPORTS ESTABLISHING A GEOGRAPHICALLY SEPARATE, SELF-SUSTAINING POPULATION OF SPRING-RUN

> *As discussed in Evaluation Criterion (g), the proposed projects should support development of a viable population of spring-run Chinook salmon within the Sacramento River Basin, in addition to those that already exist in Mill, Deer, and Butte Creeks.*

A priority within the HEA is the development of a new, geographically separate, self-sustaining population of spring-run Chinook salmon (see Section 4.2.3[c] of the HEA). NMFS has identified presently viable spring-run Chinook populations in Mill, Deer and Butte Creeks (Lindley *et al.* 2007). NMFS Approval Criteria (items a–f contained in Section 4.2.3 of the HEA) includes the development of a viable population of spring-run Chinook salmon within the Sacramento River Basin, in addition to those that already exist in Mill, Deer and Butte Creeks.

NMFS Approval Criteria (item 4.2.3[c] of the HEA) further states that, in addition to being geographically separate, the proposed actions need to provide habitat that is of sufficient quantity (e.g., watershed size of 500 $km^2$ or greater as a guideline) and quality, and sufficiently separate to support a self-sustaining population of spring-run Chinook salmon. The Yuba River Watershed drains 1,339 square miles of the western slope of the Sierra Nevada and includes portions of Sierra, Placer, Yuba, and Nevada counties (YCWA *et al.* 2007).

Implementation of the Englebright Dam Reach spawning habitat rehabilitation project and the juvenile salmonid rearing habitat enhancement project, and associated establishment of a viable spring-run Chinook salmon population in the lower Yuba River (in addition to presently viable spring-run Chinook salmon populations in Mill, Deer and Butte creeks), may satisfy the criteria of:

- *Favorable spatial separation from other spawning streams to minimize population impacts of a stream-specific adverse event (geographic distribution is favored over centralization)*

- *Supports establishing a geographically separate, self-sustaining population of Spring-Run*

### SUPPORTS SEGREGATING SPRING-RUN HABITAT FROM CENTRAL VALLEY FALL-RUN CHINOOK SALMON

*As discussed in Evaluation Criterion (f), the proposed projects should support segregation of spring-run and fall-run Chinook salmon populations. Segregating the two runs can involve creating a segregation barrier, increasing instream flow, or enhancing habitat for spring-run over fall-run Chinook.*

As previously discussed, separation may be achieved either through physical barriers or through the development of habitat conditions that favor spring-run Chinook salmon over fall-run Chinook salmon. Clearly, the intent is to achieve separation of fall-run and spring-run Chinook salmon to minimize/avoid genetic introgression, to be accomplished by reproductive isolation.

As previously mentioned, to some extent spatial and temporal segregation presently occurs in the lower Yuba River. Previously conducted reconnaissance-level redd surveys, carcass surveys, and the more intensive 2008 pilot redd survey demonstrate that the majority of redds constructed during September to early October (phenotypically consistent with spring-run Chinook salmon spawning timing) were observed in the uppermost portion of the survey area (i.e., upstream of the Highway 20 Bridge). Preliminary data obtained from early season redd surveys conducted from August 31 through October 1, 2009 demonstrate that of the total 714 redds constructed during this period throughout the lower Yuba River, 520 (73%) were constructed upstream of the Highway 20 Bridge. By contrast, redds constructed later in the season (phenotypically consistent with fall-run Chinook salmon spawning timing) were primarily observed further downstream in the lower Yuba River. Preliminary 2009 data demonstrate of the 1,598 redds constructed since October 1 through October 29, 2009, 952 (60%) were constructed downstream of the Highway 20 Bridge.

## HEA STEERING COMMITTEE OUTSTANDING QUESTIONS AND ISSUES

At the RMT meeting held on September 23, 2009, the HEA Steering Committee provided the RMT with a list of questions regarding habitat expansion project in the lower Yuba River.

## BIOLOGICAL

### 1.0 What is the potential contribution for each component of the proposed project to the Habitat Expansion Threshold?

As previously discussed, preliminary estimates indicate that spawning habitat rehabilitation in the Englebright Dam Reach of the lower Yuba River could provide additional spawning habitat for up to 4,764 spring-run Chinook salmon, and thereby achieve the specific HET to accommodate an estimated net increase of 2,000 to 3,000 spring-run Chinook salmon spawning annually. The juvenile salmonid rearing habitat enhancement project and resultant increased habitat complexity (e.g., create/restore backwater and side-channel habitat, physical structure, SRA, riparian vegetation, and instream object and overhanging cover) would provide for increased growth, protection from predators, and overall increased survival of juvenile spring-run Chinook salmon and steelhead, and thereby contribute to increased annual spawning run abundance. Preliminary estimates indicate that up to 22,450 lineal feet (4.25 miles), or 10 to 21 acres of in-river rearing habitat could be created, with an additional 10 to 20 acres of riparian habitat.

As also previously discussed, a segregation weir does not, unto itself, expand habitat and directly contribute to achieving the goals of the HET. Rather, the stated intent is to accomplish geographic distinction and thereby reduce the potential for genetic introgression between fall-run Chinook salmon and spring-run Chinook salmon. Similarly, although improved fish passage at the Corps Daguerre Point Dam would help to facilitate access to available upstream habitat, it would not expand the amount of habitat with the physical characteristics necessary to support spawning, rearing and adult holding of spring-run Chinook salmon and steelhead.

### 2.0 How would juvenile habitat enhancement and fish passage improvements translate into numbers of fish?

Explicit quantification of the “numbers of fish” associated with these two project components cannot be estimated at this time. Although estimates of benefit were provided to the HEA Steering Committee of the Englebright Dam Reach spawning habitat restoration action *via* the initial questionnaires, which have been refined in this document, the RMT is presently not prepared to provide additional quantitative estimation until the results of RMT studies currently underway are available. It is expected that results obtained through the Yuba Accord M&E Program will provide information allowing development of annual instream production estimates, relating the numbers of juveniles produced and emigrating from the lower Yuba River annually to the number of spawners. However, as previously mentioned, resultant increased habitat complexity (see above) would provide for increased growth, protection from predators, and overall increased survival of juvenile spring-run Chinook salmon and steelhead.

Also, as previously discussed, fish passage improvements at the Corps Daguerre Point Dam could be expected to reduce occurrence of disease in upstream migrating adults, provide additional opportunities for upstream spawning distribution, reduce adult pre-spawning mortality, and increase egg viability, all of which may result in the reduction in abundance and productivity of spring-run Chinook salmon and steelhead. Fish passage improvements at Daguerre Point Dam also could be expected to reduce juvenile salmonid injury, direct mortality and predation rates, and thereby potentially increase juvenile numbers and their contribution to year class strength and recruitment. Improving rearing habitat and fish passage is expected to work in concert with the improvements to spawning habitat in the Englebright Dam Reach.

### 3.0 Are there fish passage issues at Daguerre Point Dam?

[See the previous discussion of Daguerre Point Dam passage improvement considerations.]

### 4.0 Where is the best location to place a segregation weir on the Lower Yuba River?

In practical terms, there are a limited number of locations that would be most suitable for installation and maintenance of a segregation weir in the lower Yuba River. Evaluation of the technical feasibility (including potential site locations) associated with implementation of a segregation weir in the lower Yuba River remains to be conducted. At a minimum, careful consideration of the feasibility and full costs of construction of a hard-mounted fish barrier (including in-river construction techniques and impacts), the costs of developing and securing access for construction and operations, the challenges of operations and cleaning, and the risk and potential for damage by high or flood flows will need to be undertaken prior to a final decision on this potential project. If future implementation of a segregation weir in the lower Yuba River is considered, then additional monitoring (acoustic tracking, spawning surveys, genetic analysis) being conducted by the Yuba Accord RMT will provide additional information regarding the specific locational and operational considerations for the segregation weir project.

### 5.0 Where are phenotypic spring-run Chinook salmon spawning, above or below the proposed location of the segregation weir?

[See the previous discussions regarding spatial and temporal distribution of Chinook salmon spawning, and issues surrounding the segregation weir project.]

## PROJECT RELATED

### 1.0 What are the resource agencies positions on the segregation weir?

[Response to this question requires direct consultation with resource agencies]

## 2.0 Are the Narrows gravel augmentation and Daguerre Point Dam fish passage improvement actions the responsibility of the Corps under the biological opinions?

As previously described, although the cessation of spawning gravel recruitment from areas upstream of the Corps Englebright Dam may be directly attributable to the presence of the dam, some of the shot-rock on Sinoro Bar results from high flows and landslides, and the geomorphic structure also has been influenced by local instream gravel mining. The Englebright Dam Reach spawning habitat rehabilitation project proposed for HEA consideration includes shot-rock removal, localized grading and contouring, placement of hydraulic roughness elements, and initial gravel placement.

Although the Corps is required to implement a long-term gravel augmentation program by the NMFS 2007 BO, such a program would provide minimal benefits to spring-run Chinook salmon and steelhead until the channel is rehabilitated from instream gravel mining and deposition of shot-rock. After initial spawning habitat rehabilitation and the provision of gravel associated with the Englebright Dam Reach spawning habitat rehabilitation project, it is suggested that ongoing gravel supply would then be maintained as per requirements of the Corps in the NMFS 2007 BO, or whatever requirements emanate from the legal challenge pending in the United States District court for the Eastern District of California. It has been estimated that ongoing annual maintenance of the spawning habitat could be accomplished through the injection of approximately 10,000 cubic yards of gravel per year (Pasternack 2009).

Potential alternatives associated with fish passage improvements at Daguerre Point Dam continue to be part of ongoing investigations. According to the NMFS 2007 BO, the Corps shall develop and implement a plan to improve fish passage for adult and juvenile spring-run Chinook salmon, steelhead and green sturgeon at Daguerre Point Dam. Although the NMFS 2007 BO is the subject of a legal challenge pending in the United States District Court for the Eastern District of California, it is anticipated that fish passage improvements at Daguerre Point Dam will remain the Corps' responsibility.

## 3.0 Are there accurate cost estimates for the individual project components including permitting, construction, and long term operation and maintenance costs?

We have not prepared cost estimates for proposed habitat enhancement projects in the lower Yuba River. Additional cost information is provided under the previous discussion regarding feasibility, which includes economic feasibility.

## 4.0 Are there potential funding partners for operation and maintenance activities?

Anticipated potential funding partners were preliminarily identified in the questionnaire responses for each of the considered habitat expansion project for the lower Yuba River, and

were discussed above under the section titled "Relationship to Other Parties". Potential funding partners suggested in the responses to the questionnaires have not necessarily confirmed their participation or approval of identified habitat expansion projects in the lower Yuba River.

For summary purposes, information regarding potential funding partners for each of the four considered projects in the lower Yuba River is presented below.

After initial spawning habitat rehabilitation and the provision of gravel associated with the Englebright Dam Reach spawning habitat rehabilitation project, ongoing gravel supply would then be maintained as per requirements of the Corps in the NMFS 2007 BO, or subsequent requirements pending the outcome of the legal challenge being considered by the United States District Court of the Eastern District of California.

As stated in SYRCL questionnaire response, funding partners for juvenile salmonid rearing habitat enhancement project could potentially include the Corps, Western Aggregates, PG&E, BLM, USFWS AFRP, and project partners could potentially include the Corps and SYRCL. As previously discussed, potential funding partners suggested in the responses to the questionnaires have not necessarily confirmed their participation or approval of identified habitat expansion projects in the lower Yuba River. Moreover, it is likely that all of the potential funding partners have funding limits or constraints for a project of the necessary scope and magnitude.

It is presently undetermined what parties would be responsible for continued maintenance of the juvenile salmonid rearing habitat enhancement project.

As stated in SYRCL's response to the questionnaire for the segregation weir project, funding partners could potentially include PG&E and the USFWS AFRP, and project partners could potentially include the Corps. As part of the NMFS 2007 BO, the Corps shall maintain the current fish passage facilities, including fish ladder clearing and sediment management, at Daguerre Point Dam until it develops and implements a plan to improve passage at Daguerre Point Dam. Although the NMFS 2007 BO is the subject of a legal challenge pending in the United States District Court for the Eastern District of California, it is anticipated that fish passage improvements, including ongoing maintenance activities at Daguerre Point Dam will remain the Corps' responsibility.

## 5.0 Who would own, operate, and maintain a segregation weir?

It is presently undetermined what parties would be responsible for the segregation weir. As discussed above, SYRCL's questionnaire response stated that potential funding partners for segregation weir implementation could potentially include PG&E and the USFWS AFRP, and project partners involved with ongoing operation and maintenance activities could potentially include the Corps.

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