DRAFT
BATTLE CREEK SALMON AND STEELHEAD RESTORATION PROJECT

ADAPTIVE MANAGEMENT PLAN

U.S. Bureau of Reclamation

Pacific Gas and Electric Company

National Marine Fisheries Service

U.S. Fish and Wildlife Service

California Department of Fish and Game

April 2004

DRAFT
BATTLE CREEK SALMON AND STEELHEAD RESTORATION PROJECT

ADAPTIVE MANAGEMENT PLAN

Prepared for the

U.S. Bureau of Reclamation

Pacific Gas and Electric Company

National Marine Fisheries Service

U.S. Fish and Wildlife Service

California Department of Fish and Game

Prepared by

Terraqua, Inc.

Wauconda, Washington

April 2004

ACKNOWLEDGEMENTS

This Adaptive Management Plan was prepared under the direction of the Adaptive Management Parties (Pacific Gas and Electric Company, California Department of Fish and Game, U.S. Fish and Wildlife Service, and National Marine Fisheries Service) by Terraqua, Inc., under subcontract to the U.S. Bureau of Reclamation using funding provided by California Bay-Delta Authority. Significant contributions to this document were provided by the Adaptive Management Parties, Stillwater Sciences, Jones and Stokes Associates, The Nature Conservancy, Kier Associates, and Navigant Consulting. Two scientific Technical Panels established by California Bay-Delta Authority provided important comments regarding adaptive management theory and practice which prompted substantial reconception of earlier drafts. Members of the Battle Creek Working Group provided reviews and additional policy suggestions.

NOTES TO THE READER

This Adaptive Management Plan assigns specific meanings and definitions to some common words or proper nouns. Words used in the text that represent specific meanings as defined within this plan are indicated by capitalizing the first letter of each word. Definitions for these words can be found beginning on page III.D.1.

Table 1. A list of acronyms used within this report.

AFRP	Anadromous Fish Restoration Program
AMF	Adaptive Management Fund
AMP	Adaptive Management Plan
AMPT	Adaptive Management Policy Team
AMTT	Adaptive Management Technical Team
BCWC	Battle Creek Watershed Conservancy
BCWG	Battle Creek Working Group
BLM	United States Bureau of Land Management
CALFED	CALFED Bay-Delta Program
CAMP	Comprehensive Assessment and Monitoring Program
CBDA	California Bay-Delta Authority
CEC	California Energy Commission
CEQA	California Environmental Quality Act
CDFG	California Department of Fish and Game
CDWR	California Department of Water Resources
cfs	Cubic Feet per Second
CMARP	Comprehensive Monitoring, Assessment, and Research Program
CNFH	Coleman National Fish Hatchery
CNFH-AMP	Coleman National Fish Hatchery Adaptive Management Program
CRR	Cohort Replacement Rate
CVPIA	Central Valley Project Improvement Act
EPA	Environmental Protection Agency
ESA	Endangered Species Act
FERC	Federal Energy Regulatory Commission
IFIM	Instream Flow Incremental Methodology
MOU	Memorandum of Understanding
NEPA	National Environmental Policy Act
NOAA Fisheries	National Marine Fisheries Service
PG&E	Pacific Gas and Electric Company
PHABSIM	Physical Habitat Simulation
POC	Point of Contact
SNTEMP	Stream Network Temperature Model
TNC	The Nature Conservancy
TRPA	Thomas R. Payne Associates
USBR	United States Bureau of Reclamation
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
WAF	Water Acquisition Fund
WUA	Weighted Usable Area

PUBLIC INVOLVEMENT

The public is invited to participate in the implementation of this Adaptive Management Plan (AMP). While many lay readers may find this AMP to be dry and technical in many cases, opportunities for public involvement are built into adaptive management throughout this document. This section highlights some of the ways that the public may be involved with adaptive management in Battle Creek and points to specific sections of the document for more information. Figure 1 illustrates some of the relationships between adaptive management and public involvement. Figure 2 provides a general illustration of the complex restoration activities in Battle Creek.

- The development of the Battle Creek Salmon and Steelhead Restoration Project and this AMP were done with full public participation in accordance with all public laws and regulations. The implementation of the Restoration Project and AMP will continue to be open to the public.

- Adaptive management in Battle Creek will involve extensive field studies and monitoring. Any adaptive management activities on private lands must meet strict performance protocols. See Section III.D.6 for details.

- All data collected during adaptive management monitoring will be made available to the public by dissemination to the appropriate agency information storage systems and an information system operated and maintained by the Battle Creek Watershed Conservancy (BCWC). An important exception, designed to protect the privacy of private landowners, involves incidental observations. Section III.D.6 states, in regards to monitoring on private lands, that "*Field personnel will record only data that meets the purpose of the visit. Incidental observations will not be recorded or shared with the public, but may be shared with the landowner upon request at any time. Field personnel will not discuss specifics of data collected from private properties with anyone outside of the staff designated by the AMP data management protocols.*"

- Most monitoring activities will be funded through public funding sources (with the exception of those activities funded by the hydroelectric project Licensee). The public is invited to participate in decision making related to these public funding sources. See Section III.D.4.

- All technical and decision-making meetings will be open to the public. In most cases, adaptive management meetings will be formally announced at least one month in advance. Exceptions to this announcement procedure may occur in the case of emergencies when ad hoc meetings may be scheduled. In any case, the public is welcome to attend. See Section III.D.8 for details on meeting schedules and process.

- Any person requesting notification of adaptive management meetings will be provided with such notice. See Section III.D.8 for details.

- Local landowners, watershed residents, and other members of the BCWC are given special recognition within this document. While these people may be fortunate to benefit most directly from restored salmon and steelhead populations in their own watershed, and from learning opportunities afforded by the project to local schools and residents, they also have unique burdens that come with the high level of monitoring activities within their watershed. Section 0 discusses the unique role of the BCWC in adaptive management.

- Local landowners, watershed residents, and other members of the public have an opportunity to participate in discussion of watershed issues within Battle Creek through participation in the Greater Battle Creek Working Group. The Greater Battle Creek Watershed Working Group provides an open forum for coordinating adaptive management activities among various entities.

Research Invitation

Scientific reviewers of the Battle Creek Salmon and Steelhead Restoration Project have recognized that the Restoration Project is an "extremely important opportunity" to learn about the value of many salmon restoration activities and how similar activities could benefit the restoration of other fish populations in California and the Pacific Northwest. Every effort should be made to guarantee that we learn from this valuable opportunity. Independent researchers are invited to participate in the learning opportunities inherent in this project. Interested researchers are encouraged to coordinate with the Adaptive Management Policy Team to explore opportunities for research in Battle Creek. All research in Battle Creek must follow appropriate laws and regulations, including permitting, and must observe the rights of private property owners. Interested researchers are encouraged to adhere to protocols described in Section III.D.6 regarding research on private property.

Document Road Map

The table of contents, list of figures, and list of tables are handy ways to understand the layout of this document. Section I.G provides additional detail on this document's organization.

The reader interested in skimming the highlights of this AMP may wish to skip to the following AMP features:

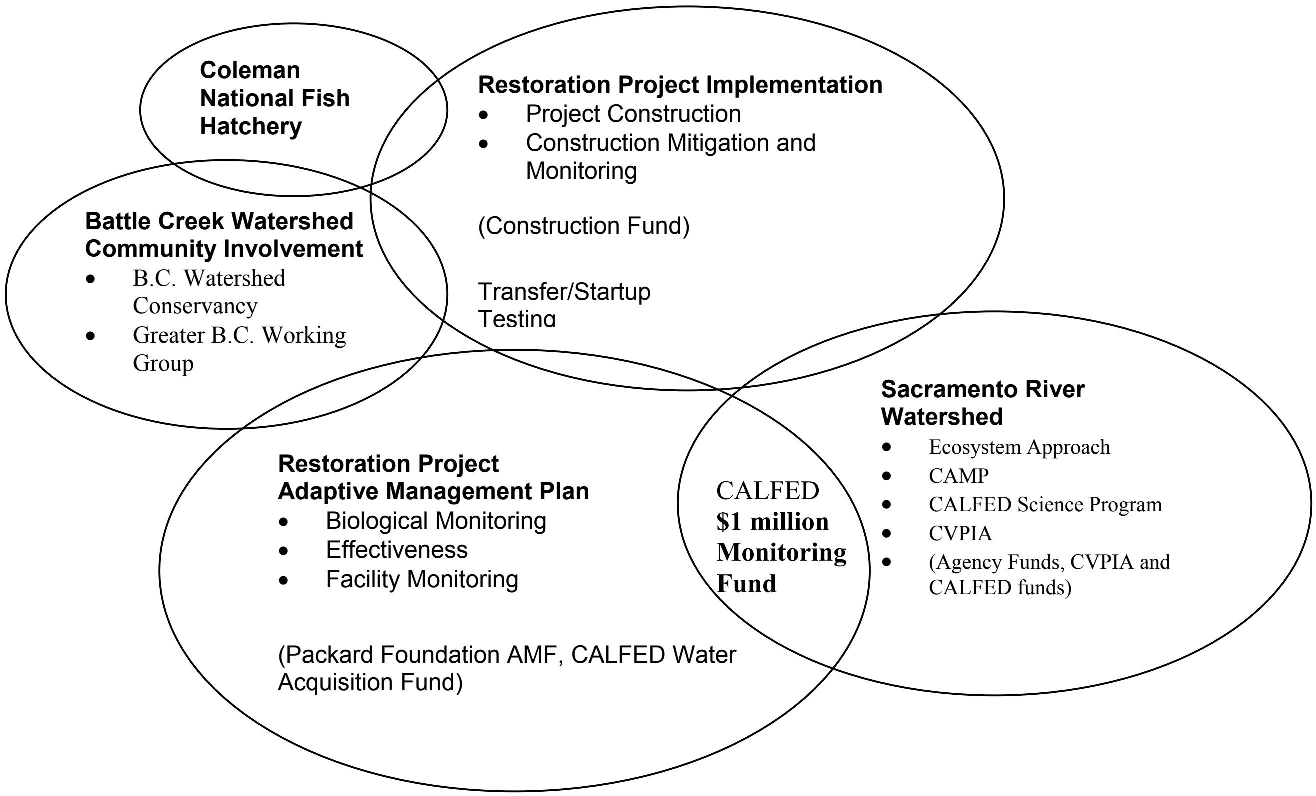


Figure 1. Institutional and funding relationships described in the Battle Creek AMP with related watershed restoration programs and community involvement.

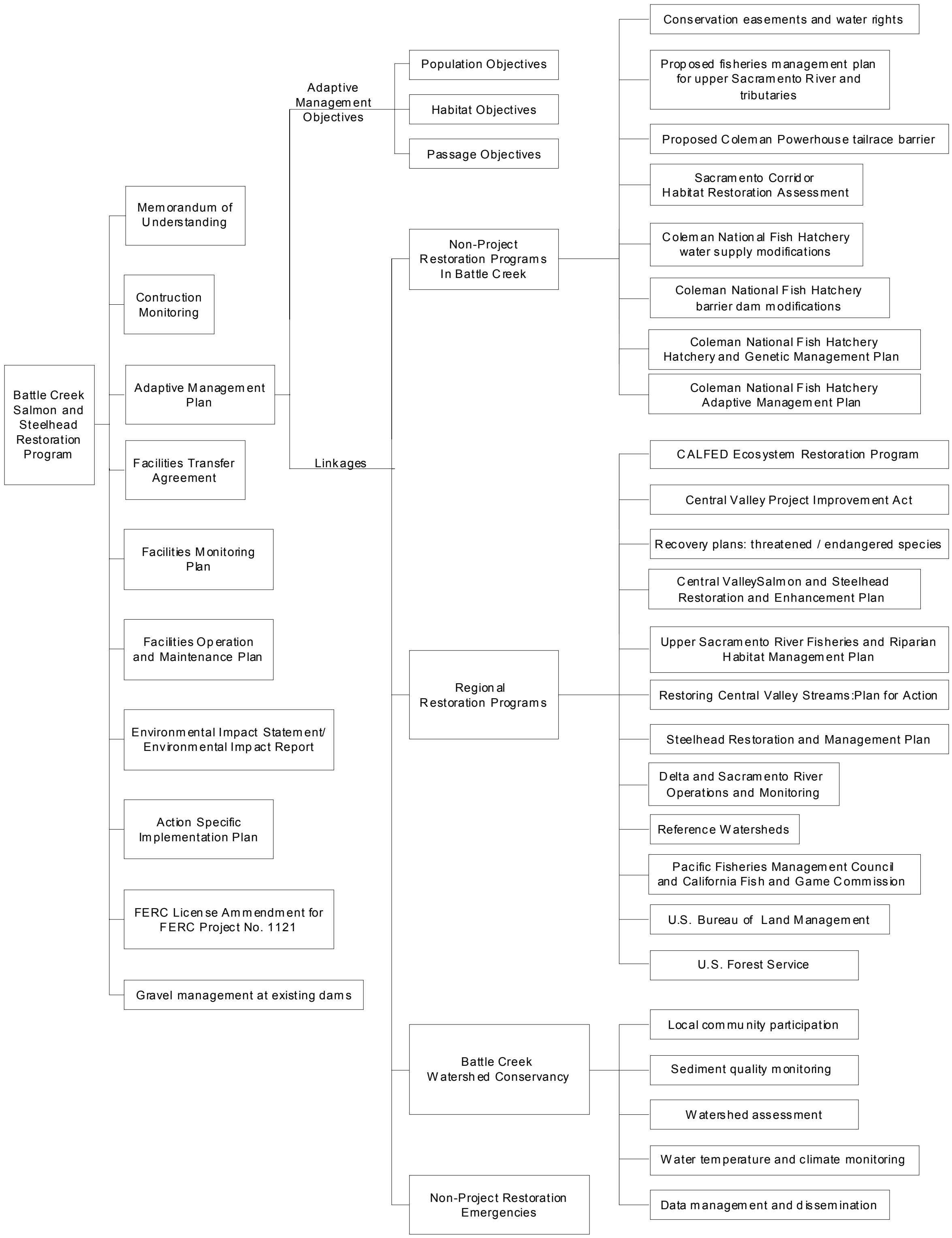


Figure 2. Schematic of the relationship of the AMP and Adaptive Management objectives with other Restoration Project and non-project restoration activities that may affect salmon and steelhead in Battle Creek.

PREFACE

Battle Creek has historically been regarded as a uniquely important salmon-producing watershed because of the large numbers and broad diversity of Chinook salmon and steelhead that have historically used this stream. The importance of restoring the fish habitat and populations within Battle Creek has long been recognized, but the urgency of the ongoing Battle Creek Salmon and Steelhead Restoration Project is heightened by the fact that this watershed is home to winter-run Chinook salmon, spring-run Chinook salmon, and steelhead, all of which are in danger of or threatened with extinction as defined by the federal Endangered Species Act (ESA). Furthermore, Battle Creek provides the only remaining accessible habitat in the Sacramento River watershed, other than the Sacramento River itself, that may be suitable for populations of winter-run Chinook salmon.

The primary goal of the Restoration Project is to restore and enhance about 42 miles of anadromous fish habitat in Battle Creek and an additional 6 miles of habitat in its tributaries while minimizing the loss of renewable energy produced by the Battle Creek Hydroelectric Project. The Restoration Project has been the result of a long planning process that culminated in a Memorandum of Understanding (MOU) between the Resource Agencies and Pacific Gas and Electric Company (PG&E). An integral part of the MOU was the direction to develop and implement an adaptive management program to monitor the effectiveness of restoration actions taken and make further adjustments to Hydroelectric Project facilities or operations as appropriate in pursuit of the primary goal of the Restoration Project.

Therefore, this document is the strategic plan agreed upon by the Resource Agencies and PG&E. Its goal is to implement specific actions to protect, restore, enhance, and monitor salmonid habitat at the Hydroelectric Project to guard against false attraction of Chinook salmon and steelhead, and to ensure that these fish in all life stages are able to fully access and beneficially use available habitat, thereby maximizing natural production and the full use of ecosystem carrying capacity. While this Plan was written primarily to conform to provisions of the MOU, it is also recognized that this Plan may assist the Federal Energy Regulatory Commission (FERC) regulating license compliance and may be incorporated as part of, or at least linked to, other Battle Creek watershed and statewide resource management efforts. Because this plan is intended specifically to apply to the Restoration Project and is not a general watershed management plan, its objectives and protocols must be evaluated in light of these stated purposes.

EXECUTIVE SUMMARY

The Battle Creek Salmon and Steelhead Restoration Project is a joint effort between PG&E, the National Marine Fisheries Service (NOAA Fisheries), California Department of Fish and Game (CDFG), U.S. Fish and Wildlife Service (USFWS), and U.S. Bureau of Reclamation (USBR) to restore salmon and steelhead runs in the Battle Creek watershed while maintaining the renewable energy production of the Battle Creek Hydroelectric Project (FERC Project No. 1121). A MOU was adopted in June 1999 stating the intent of the MOU Parties to engage in a restoration effort that would modify the facilities and operations of FERC Project No. 1121. The objectives of the Restoration Project are (1) the restoration of self-sustaining populations of Chinook salmon and steelhead and their habitat in the Battle Creek watershed, (2) up-front certainty regarding specific restoration components, (3) timely implementation and completion of restoration activities, and (4) joint development and implementation of a long-term AMP with dedicated funding sources to ensure the continued success of restoration efforts under this partnership.

The MOU identifies Adaptive Management as an important component of the Restoration Project (Figure 1). Adaptive Management uses extensive monitoring to identify problems, examine possible solutions for meeting the biological objectives, and if needed, allow changes to Contemporary strategies and actions within established limits to try to achieve the objectives and desired results. The Adaptive Management concept was formalized in this AMP developed by the PG&E, NOAA Fisheries, USFWS, and CDFG (collectively known herein as the "Parties"). Funding for implementation of the AMP is provided by the CALFED Monitoring Fund, the Water Acquisition Fund (WAF), the Adaptive Management Fund (AMF), and Licensee (PG&E).

The AMP provides guidance on implementing the Adaptive Management provisions of the MOU, and is intended to be consistent with the terms of the MOU. Any cases where the language in the AMP may conflict with the language in the MOU represent an oversight in the AMP. Therefore, the MOU prevails in any discrepancy that may be discovered between the AMP and the MOU.

The AMP was developed by Consensus between the Parties under the Adaptive Management Policy Team (AMPT) and the Adaptive Management Technical Team (AMTT). The AMPT consists of management-level representation from each of the Resource Agencies and the Licensee and is authorized to make all final decisions regarding the implementation of the AMP and to provide policy direction and dispute resolution on issues forwarded to it by the AMTT. The AMTT consists of technical experts from each of the Resource Agencies and the Licensee and is responsible for the development and implementation of the AMP portion of the Restoration Project when it has been approved by FERC. Definitions are provided in the AMP to minimize confusion and to simplify the text. Words or phrases defined in the AMP appear capitalized within this plan.

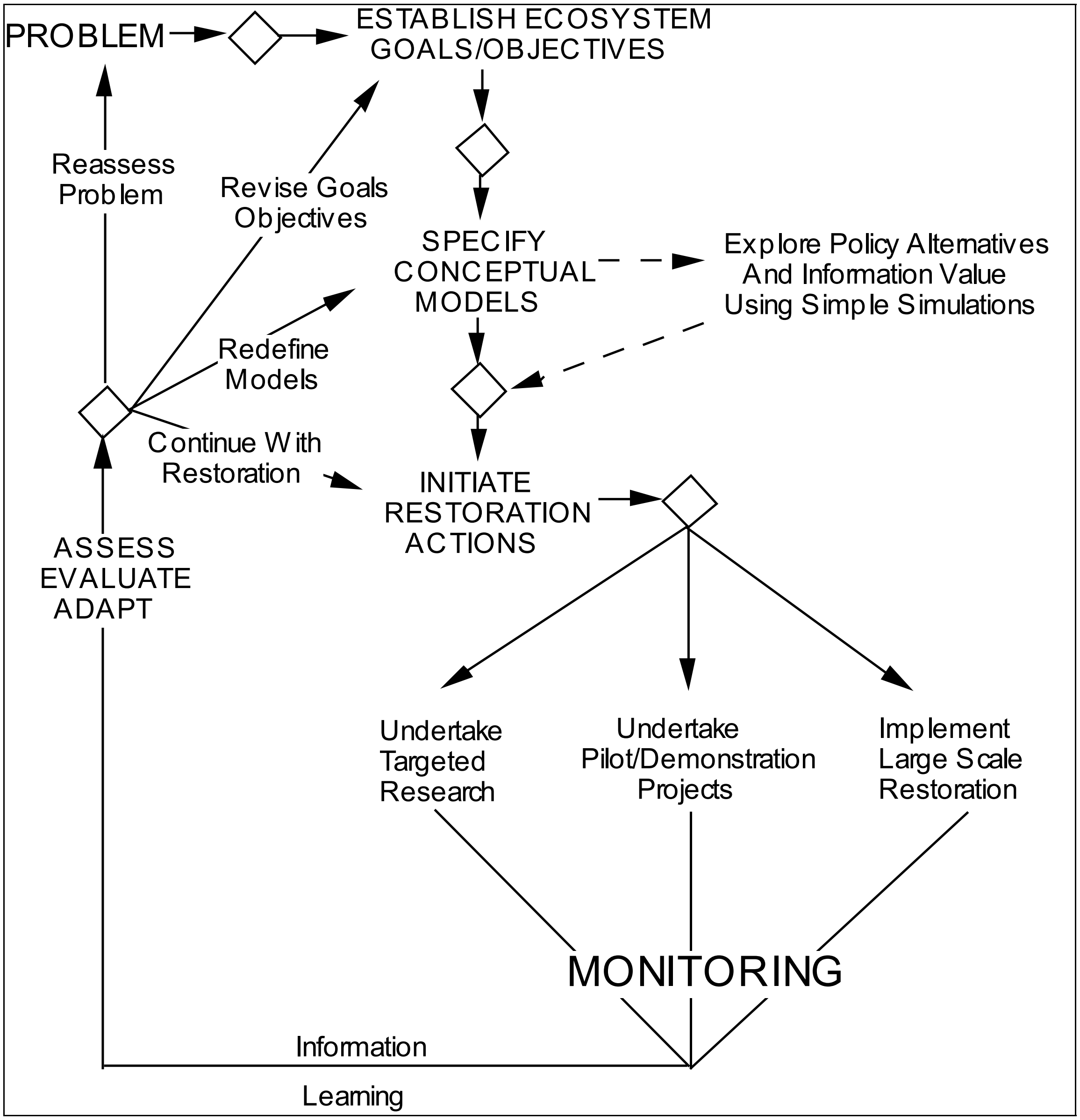


Figure 3. CALFED schematic of adaptive management.

Roles and responsibilities of the Parties pertaining to the AMP portion of the Restoration Project are listed in detail. The Licensee has agreed to a number of physical and operational changes and additions to FERC Project No. 1121 and has agreed to assume 90 percent of the initially forecast costs associated with the loss of power generation as well as other future costs. These include, but are not limited to, cost overruns for which the Licensee is responsible, future authorized facilities modifications or increased instream flows in the event the WAF and AMF are depleted, internal costs associated with providing expertise in the AMP process, and the loss of power associated with meeting instream flow releases and Ramping Rate requirements. Upon completion of facility start-up and testing, Licensee is responsible for the operation, maintenance, replacement, and successful operation of all physical modifications to its facilities under the MOU. Licensee is also responsible for all facility and other monitoring required by the FERC license amendment for FERC Project No. 1121. NOAA Fisheries responsibilities are those it determines consistent with its mandate under the ESA. NOAA Fisheries also has the responsibility of defining recovery goals for salmon species listed under the ESA. Together the USFWS and CDFG agree to support the prescribed instream flows and Ramping Rates described in the MOU, or agreed upon through the Adaptive Management in the next relicensing proceeding for FERC Project No. 1121. USFWS and CDFG are also jointly responsible for conducting or funding a variety of monitoring, data collection and assessment, and report preparations associated with various fish population objectives. In addition, all Parties will be responsible for providing at least one representative to the AMPT and the AMTT and assuming all responsibilities and costs associated with these positions. All Parties will be individually responsible for any costs associated with their involvement in any FERC dispute resolution proceedings.

Sources of funding for the implementation of the AMP identified to date are the CALFED Monitoring Fund, the WAF, the AMF, and the Licensee. The CALFED Monitoring Fund of $1,000,000 is intended for monitoring costs associated with the Restoration Project. The WAF is a federal fund of $3,000,000 administered by the Resource Agencies per AMP protocols and intended for the sole purpose of acquiring additional instream flow releases in Battle Creek recommended under the AMP for a ten year period following the initial prescribed instream flow releases. The AMF of $3,000,000 is for the purpose of funding possible future changes to the Restoration Project developed under the AMP. The AMF is to be limited to actions under the Restoration Project directly associated with FERC Project No. 1121, and is expressly not available for funding of monitoring or construction cost overruns. In the event of the exhaustion or termination of the WAF, the AMF may be used to secure additional instream flow releases developed under the AMP. In the event of exhaustion of the WAF and AMF, the Licensee has committed up to a total of $6,000,000 for all Adaptive Management actions for Authorized Modifications to project facilities or flow operations which are determined to be necessary under Adaptive Management.

The AMP closely follows Contemporary theoretical and practical standards of adaptive management. Adaptive Management used in this plan includes elements of and, therefore, is a form of “active” adaptive management. However, because specific experimentation of instream flows and facilities modifications were not initially designed into the implementation of the AMP, the AMPT characterizes the restoration of Battle Creek as Passive Adaptive Management where changes in management are made in response to monitoring results.

The AMP bridges the theoretical and practical aspects of adaptive management by building a logical span between scientific knowledge and uncertainties, on the theoretical side, to monitoring activity schedules and budgets at the purely practical end. In between is a strong infrastructure of conceptual models and Adaptive Management Objectives.

The reader interested in skimming the essence of this AMP, that is to quickly view the bridge between adaptive management theory and practice as applied in Battle Creek, may wish to skip to the following AMP features:

The Adaptive Management objectives outlined in the AMP focus on management of hydroelectric operations within the Restoration Project to facilitate habitat changes beneficial to salmon and steelhead. There is expected to be a corresponding increase in salmon and steelhead populations as a result of these management actions. Measuring such increases is practical for larger populations such as steelhead and fall-run Chinook salmon, but proving statistically significant responses to fish populations currently at extremely low levels, such as winter-run Chinook, may not be possible. Therefore, trigger events leading to Adaptive Management actions will not be based solely on populations data, but will also rely on measurements indicating habitat conditions. The AMP objectives do not include or exclude existing or potential future propagation or supplementation activities, nor do they include specific "active" experimentation of proposed instream flows or experimental changes to hydroelectric project facilities to elucidate relationships between management actions and ecological processes, nor do they address the possibility of future development within Battle Creek.

Although many anticipated limiting factors as well as many unanticipated circumstances have been outlined in the AMP, the plan acknowledges that not all events are predictable and, invariably, surprising circumstances will arise. However, it is the nature of Adaptive Management to design studies and management programs to adapt to unforeseen circumstances. Also, many unanticipated factors may be outside the scope of the Restoration Project. Just how an AMP responds to new circumstances is governed by a stepwise scientific process beginning with hypothesis testing of objectives through monitoring and data assessment. A timeline identifies the duration and order of monitoring activities and includes trigger events indicating that an Adaptive Management response is necessary. Adaptive Management responses would be evaluated to determine if the objective is being met and current actions should continue or if new actions are needed to meet the objectives. Adaptive Management responses could include any major or minor changes to the hydroelectric facility or the natural features of the Restoration Project. Responses to a trigger event will have limits identified by the FERC license amendment. Adaptive Management responses falling outside of those allowed by the FERC license amendment provisions would need to be addressed through established FERC processes. Key to the Adaptive Management process is a reporting regime consistent with the ability to design and evaluate responses to Adaptive Management actions.

The AMP objectives for the restoration of salmon and steelhead focus on improvements in population dynamics, improvements to the habitat, and improvements designed to ensure safe passage of adults and juveniles. The population objectives are (1) ensure successful salmon and steelhead spawning and juvenile production, (2) restore and recover the assemblage of anadromous salmonids (i.e., winter-run Chinook, spring-run Chinook, steelhead) that inhabit the stream's cooler reaches during the dry season, (3) restore and recover the assemblage of anadromous salmonids (i.e., fall-run Chinook, late fall-run Chinook) that enter the stream as adults in the wet season and spawn upon arrival, and (4) ensure salmon and steelhead fully utilize available habitat in a manner that benefits all life stages, thereby maximizing natural production and full utilization of the ecosystem carrying capacity. Objectives focusing on improving the habitat of salmon and steelhead are (1) maximize habitat quantity through changes in instream flow, (2) maximize habitat quantity by ensuring safe water temperatures, (3) minimize false attraction and harmful fluctuation in thermal and flow regimes resulting from planned outages or detectable leaks from the hydroelectric project, and (4) minimize the stranding and isolation of salmon and steelhead resulting from variations in flow regimes caused by hydroelectric project operations. Objectives for the safe and reliable passage of salmon and steelhead are (1) provide upstream passage of adults at dams, (2) provide downstream passage of juveniles at dams, and (3) provide upstream passage of adults to their appropriate habitat over natural obstacles while ensuring appropriate levels of spatial separation between runs.

To determine if the population objectives of the AMP are being met, assessments of population size, trends in productivity, population substructure, and population diversity must be compared to corresponding guidelines set forth by NOAA Fisheries. The AMP has adopted NOAA Fisheries definitions of "viable populations" as the intermediate population goal and identifies the maximization of salmon and steelhead production and full utilization of carrying capacity as the final goal. The fish passage objectives are intended to assist in restoring natural process of dispersal and the habitat objectives will work to restore natural ecological variation associated with the natural function of the ecosystem. Further threats to population diversity not covered by the AMP objectives will be addressed through the AMP "linkages."

The AMP is just one aspect of the Restoration Project and is closely linked with the other elements of the Restoration Project. Other programs within the Restoration Project cover some aspects of restoration not covered in the AMP such as facility operations and maintenance. The AMP is also linked to non-project restoration programs affecting salmon and steelhead populations both within and outside the Battle Creek watershed.

The implementation of the AMP is governed by a set of protocols. Adaptive Management activities on private land will be conducted in a manner that respects landowners' rights and privacy and that minimizes disturbances and risks to private lands. Protocols governing data management are consistent with guidelines established by Comprehensive Monitoring, Assessment, and Research Program (CMARP) and the Environmental Protection Agency (EPA). Data and information will be made available to the public by dissemination to the appropriate agency information storage systems and an information system operated and maintained by the BCWC.

Meetings of the AMTT will be scheduled four times per year including an annual meeting in March, when possible Adaptive Management actions will be considered. The AMPT will meet at least annually in late March. These March meetings of the AMTT and AMPT are scheduled to finalize annual reports in time for funding agency deadlines. Ad hoc meetings may be scheduled by the AMTT or AMPT to address emergencies without advanced public notice, but such meetings will only consider the emergency at hand. All meetings will be open to the public, and all scheduled meetings will be announced to the public. Protocols also specify meeting announcement requirements, voting rules, report writing, Adaptive Management responses, proposal ranking, modification of Adaptive Management objectives, and dispute resolution.

Several Focused Studies were developed to address uncertainties and learning opportunities that may not be directly addressed by Adaptive Management objectives. These are listed in the final ten sections of the document.

TABLE OF CONTENTS

LIST OF CONCEPTUAL MODELS

LIST OF FIGURES

LIST OF TABLES

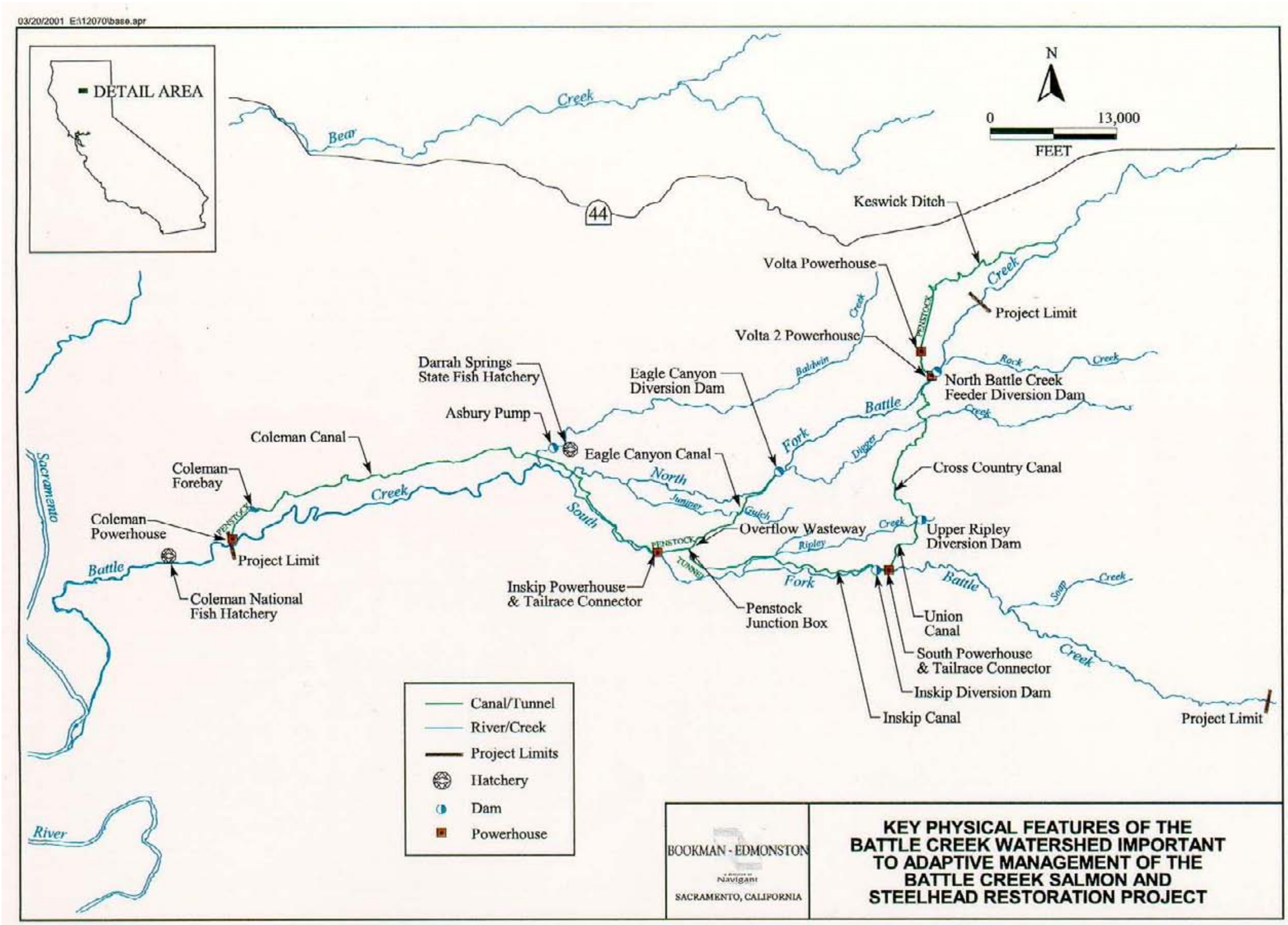


Figure 4. Location Map: Battle Creek Salmon and Steelhead Restoration Project

I. BATTLE CREEK RESTORATION PROJECT DESCRIPTION

I.A. Setting

Battle Creek is a tributary of the Sacramento River located in Tehama and Shasta Counties. This cold, spring-fed stream has exceptionally high flows during the dry season, making it important habitat for anadromous fish. Battle Creek may be the only remaining stream other than the main stem of the Sacramento River that can successfully sustain breeding populations of steelhead and all four runs of Chinook salmon. Battle Creek is also unique and biologically important because its numerous cold-water springs provides habitat opportunities during drought years for winter-run Chinook salmon.[1]

Pacific Gas and Electric Company (PG&E) owns and operates several hydroelectric power diversion facilities on the North and South Forks of Battle Creek, including Coleman Division Dam, Inskip Diversion Dam, South Diversion Dam, Wildcat Diversion Dam, Eagle Canyon Diversion Dam, and North Battle Creek Feeder Diversion Dam, and dams on Ripley Creek, Soap Creek, and Baldwin Creek. PG&E controls the majority of the flows in the anadromous fish reaches of the Battle Creek watershed.[2]

Salmonid populations, in general, can be affected by a recurring suite of limiting factors. In Battle Creek, many of these typical problems are unlikely to occur due to particular watershed features, including:

- No surface water diversion occur in the forks or mainstem of Battle Creek within the project area (i.e. between Coleman Powerhouse and the upstream limits of anadromy) other than the hydroelectric project; this limits the number of dams and diversions that need to be considered.
- The existing hydro system has negligible effect on high-flow events and the wet season hydrograph due to the absence of reservoirs with significant storage capacity. This limits the projects effects on channel maintenance and stability, flushing flows and smolt out migration.
- High volume, cold (52°F) springs in both forks of the creek can be redirected to adjacent stream reaches to form cold-water refuges. Battle Creek is the most spring dominated watershed within the remaining anadromous habitat of Central Valley.
- Existing hydro system dams do not significantly alter sediment routing through the system at high flows. The dams are low (10 to 28 ft. in height) narrow structures full of sediment leaving them with little or no trap efficiency. In addition, the dams all include large sluice gates 10 to 25 sq. ft. operated several times a year during high flow to pass any accumulated sediment in the vicinity of the gates.

[1] MOU 1.1
[2] MOU 1.2

- Land use dominated by large ranches (average parcel size is 400 acres in anadromous zone) that isolate the creek from development and public access disturbances. Conservation easements are being established throughout the watershed to further buffer the stream.
- Topography in anadromous habitat, especially steep inner canyons, virtually isolate the stream from typical threats like cattle grazing, roads, and near stream logging.
- Geology/soil types of the anadromous zone and much of the rest of the watershed is resistant to surface erosion and mass-wasting,
- Within the watershed there are key activities under the control of other entities that are closely linked to the Restoration Project; specifically the operation of the Coleman National Fish Hatchery (CNFH) which is being addressed by the California Bay-Delta Authority (CBDA) Science Program workshop and reconsultation under Endangered Species Act (ESA) when the Restoration Project is complete. The potential role of the CNFH is also addressed in the current Winter-run Recovery Plan (1997). The Greater Battle Creek Watershed Working Group provides an open forum for coordinating adaptive management activities among various entities.

Several of the problems which typically affect salmonid populations are believed to occur in Battle Creek due to particular watershed features, including:

- Inadequate instream flow during the base flow period when approximately 97 percent of the unimpaired runoff is diverted out of the stream channel into adjacent canals. (See attached water budget from Thomas R. Payne Associates (TRPA) Battle Creek Hydrology Study)
- Passage problems due to low flow over natural obstacles in the stream channel and inadequate ladders on dams. Ladders fail current standards of conveying 10 percent of the stream flow by one order of magnitude. In addition, ladders are vulnerable to failure from debris (especially Alaska Steep pass units) and they are all situated on dams where they cannot be cleared of debris during wet season.
- Temperature problems for cold-water fish species result from diversion of cold-water springs on both forks directly into canals and away from adjacent stream channels. In addition, lower flows resulting from hydropower diversions increase the heat gain as the water travels down the canyon.
- Entrainment resulting from no fish screens and extremely high percentage of flow diverted (up to 97 percent of base flow).
- Powerhouse operations disrupt stream function and stability by: 1) causing rapid flow fluctuations of up to 200 cfs which can lead to redd-dewatering, and stranding and isolation of juvenile fish, 2) causing rapid changes in water temperature regime, and 2) diverting as much as 97 percent of the water from the North Fork into the South Fork leading to potential false attraction of returning adults to non-natal habitat that is at risk of rapid, detrimental fluctuations in water temperature.

I.B. Restoration Project Components[3]

The proposed Battle Creek Salmon and Steelhead Restoration Project includes the following elements (see Table 2 for a summary):

I.B.1. Facility Modifications[3]

A. Coleman Diversion Dam:

- Install a tailrace connector from Inskip Powerhouse to Coleman Canal and a water bypass facility around Inskip Powerhouse to Coleman Canal. The Inskip Powerhouse bypass facility will be the most economical alternative that still provides the functional equivalent of the existing Inskip Powerhouse bypass system and will deliver that system's design flow of water to the Coleman Canal.
- Decommission the dam and appurtenant facilities.

B. Inskip Diversion Dam:

- Install a National Marine Fisheries Service (NOAA Fisheries)/California Department of Fish and Game (CDFG) approved Fail-Safe Fish Screen.
- Install a NOAA Fisheries/CDFG approved Fail-Safe Fish Ladder.
- Install a tailrace connector from South Powerhouse to Inskip Canal concurrent with, or prior to, the Inskip Diversion Dam fish screen.

C. South Diversion Dam:

- Decommission the dam, related water conveyance and appurtenant facilities.

D. Wildcat Diversion Dam:

- Decommission the dam, related water conveyance and appurtenant facilities.

E. Eagle Canyon Diversion Dam:

- Install a NOAA Fisheries/CDFG approved Fail-Safe Fish Screen.
- Install a NOAA Fisheries/CDFG approved Fail-Safe Fish Ladder.
- Decommission spring collection facilities as identified in Memorandum of Understanding (MOU) Table 1 of MOU Attachment 1.

F. North Battle Creek Feeder Diversion Dam:

- Install a NOAA Fisheries/CDFG approved Fail-Safe Fish Screen.
- Retrofit the existing fish ladder or install a new ladder, either which meet NOAA Fisheries/CDFG approved design for Fail-Safe operation.

G. Soap Creek:

- Decommission the dam, related water conveyance and appurtenant facilities.

[3] MOU 4.0.

H. Lower Ripley Creek:

- Decommission the dam, related water conveyance and appurtenant facilities.

I. Baldwin Creek:

- Provide a means for releasing a maximum instream flow of 5 cfs from Asbury Pump Diversion.

J. Various Locations:

- Install/modify gages at appropriate locations required to monitor implementation of the Restoration Project.

While the above list of facilities to be decommissioned shall not be reduced, the Parties may reach Consensus on less than full removal of any specific facility or appurtenant feature in order to reduce overall Restoration Project costs, where objectives of the Restoration Project, including unimpeded fish passage, will be met while at the same time minimizing PG&E liability.

I.B.2. Prescribed Instream Flow Releases[3]

The MOU states as follows:

> "The Parties agree that another component of the Restoration Project is an increase of prescribed instream flow releases which will benefit fish and wildlife resources. PG&E will provide the prescribed instream flow releases specified in MOU Tables 1 and 2 of MOU Attachment 1 or the natural flow, whichever is less, and the Ramping Rates specified in MOU Attachment 2. For those dams that are being decommissioned, PG&E will transfer the associated water diversion rights to CDFG.
>
> "At the discretion of the Resource Agencies, the prescribed instream flow releases will be initiated and maintained commencing January 1, 2001, or upon issuance of the Final FERC Order, whichever occurs later. Should any such prescribed instream flow releases not commence on January 1, 2001, the associated foregone power generation payment specified in MOU Section 10.2 shall be reduced in proportion to the time at which power generation is actually foregone."

I.B.3. Water Acquisition Fund[3]

This component of the proposed Restoration Project is described in III.D.4.b.

I.B.4. Adaptive Management Plan[3]

This component of the proposed Restoration Project is the topic of this document.

I.B.5. Adaptive Management Fund[3]

This component of the proposed Restoration Project is described in III.D.4.c.

I.B.6. Gravel Management at Existing Dams

Early Diagnostic Studies indicated that system-wide sediment transport is likely not significantly affected by the existing hydroelectric project infrastructure (Kondolf and Katzel 1989; Greimann 2001). The lack of significant hydroelectric project effect on overall sediment transport is likely due to the practice of sluicing sediment through radial sluice gates at each dam during high flows. This practice was recommended in the Kondolf and Katzel (1989) as the most effective sediment management action. Kondolf and Katzel (1989) also recommended to formalize the sluicing practice and to preclude future gravel extraction from the channel. These actions are now included within the streambed alteration permit issued to PG&E from CDFG.

In light of these findings and permitting assurances, gravel management at existing dams was not considered an important element to include within the MOU for the Restoration Project. Likewise, the Adaptive Management Technical Team (AMTT) initially chose not to identify changes to sediment transport as a Restoration Project-related objective.

Recent re-analysis by Roberts (2004) of existing data and reports has confirmed the findings of Kondolf and Katzel (1989) and Greimann (2001). However, the AMTT has determined that a significant amount of associated scientific uncertainty exists regarding short-term channel and sediment transport response to dam removal in the immediate area of the dam sites. Also, this gravel management program can be interpreted as a Restoration Project action because the Federal Energy Regulatory Commission (FERC) license amendment process and the EIR/EIS process for the Restoration Project have been combined. Therefore, for the purpose of this Adaptive Management in Battle Creek, the management of gravel at existing dams will be considered a component of the Restoration Project and the AMTT has responded by developing a Focused Study of this topic.

Table 2. Components of the Battle Creek Salmon and Steelhead Restoration Project.

Site Name	Component
North Battle Creek Feeder Diversion	55-cfs fish screen Fish ladder
Eagle Canyon Diversion	70-cfs fish screen Fish ladder
Wildcat Diversion	Dam and appurtenant facilities removed
South Diversion	Dam and appurtenant facilities removed
Soap Creek Feeder Diversion Dam	Dam and appurtenant facilities removed
Inskip Diversion and South Powerhouse	220-cfs fish screen Fish ladder Construction of South Powerhouse and Inskip Canal connector (tunnel)
Lower Ripley Creek Feeder Diversion	Dam and appurtenant facilities removed
Coleman Diversion and Inskip Powerhouse	Dam removed Construction of Inskip Powerhouse and Coleman Canal connector Inskip Powerhouse bypass replaced
Asbury Diversion Dam	Reoperate Stream gaging station installed Minimum instream flow set for Baldwin Creek

I.C. Conceptual Models

Conceptual models provide the explicit link between goals and objectives and restoration actions. Conceptual models are simple depictions of how different parts of the ecosystem are believed to work and how they might respond to restoration actions. These models are explicit representations of scientists' or resource managers' tacit understandings and beliefs. Conceptual models are then used to develop restoration actions that have a high likelihood of achieving an objective while providing information to increase understanding of ecosystem function and, in some instances, to resolve conflicts among alternative hypotheses about the ecosystem. The process of adaptive management can be enhanced when conceptual models are developed into simple computer simulations that can be used to explore the consequences of alternative options for restoration (Healey and Kimmer 1998).

The Adaptive Management process envisioned for Battle Creek is as endorsed in the CALFED Bay-Delta Program (CALFED) Strategic Plan, Healey (2001), and Castleberry et al. (1996) regarding instream flow prescriptions. Adaptive Management used in this plan includes elements of experimentation (see the detailed discussion of experimentation in Section II.C) and, therefore, is a form of "active" adaptive management. However, because specific experimentation of instream flows and facilities modifications were not initially designed into the implementation of the Adaptive Management Plan (AMP), the Adaptive Management Policy Team (AMPT) characterizes the restoration of Battle Creek as Passive Adaptive Management where changes in management are made in response to monitoring results.

I.C.1. Watershed-Based Assessment of Limiting Factors

The assessment of factors limiting populations of anadromous salmonids in Battle Creek followed a life-cycle and watershed-based approach (Ward and Kier 1999a). This approach considered all the usual impacts to salmonid populations including changes to freshwater habitat, harvest influences, hydropower facilities and hatchery effects. Section II.B describes the process of identifying limiting factors in more detail; these steps are illustrated in Conceptual Model 1.

The Restoration Project and this AMP focuses on improvements designed to reduce factors limiting freshwater life stages of anadromous salmonids affected by the Battle Creek Hydroelectric Project. Other limiting factors (e.g. harvest, hatcheries, other habitat issues) are identified in this AMP but are more appropriately addressed by other programs. The "Linkages with Other Programs" Section III.E describes these other programs in more detail.

I.C.2. Restoration Project Development Process

The process by which the Restoration Project was developed is described in detail in Section II.B and is illustrated in Conceptual Model 2. The initial process and concepts were guided by several previous restoration planning efforts (e.g. Hallock 1987, see Section for many others) and were shaped by several legal mandates (e.g. Anadromous Fish Restoration Plan, USFWS 2001b; see Section II.B for many others). Within this framework, several stakeholder groups, PG&E (the owner of the Hydroelectric Project) and state and federal agencies worked together within the Battle Creek Working Group (BCWG) forum to review available information, to identify the problems facing anadromous salmonids in Battle Creek, to screen alternate solutions, and to identify a restoration project that was technically feasible, acceptable to the community, stakeholders, and PG&E, and which met numerous policy constraints. Eventually, elements of what would become the Restoration Project were identified and further refined through direct negotiations with PG&E culminating in the MOU which became the foundation for the Restoration Project. This AMP is one specific component of the MOU.

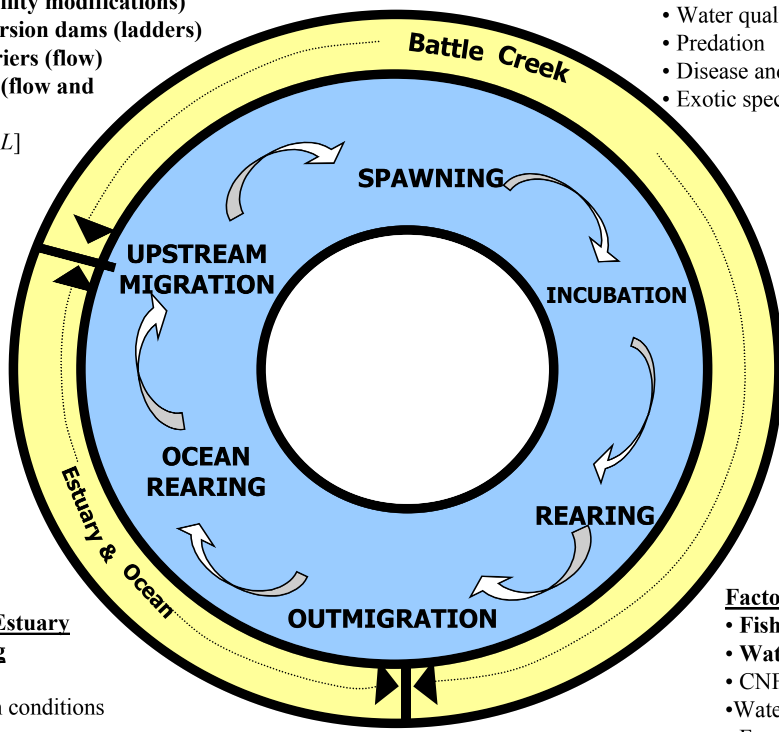
I.C.3. Adaptive Management Development Process

The process by which this AMP was developed is described in detail in Section II.B. The Restoration Project components and ecological processes which are treated in and is illustrated in Conceptual Model 3.

Key
- **Factors in Bold are addressed by Restoration Project**
- [*L*] Indicates factors addressed through linkages to other programs.

Factors Affecting Upstream Migration
- **False attraction (facility modifications)**
- **Fish passage at diversion dams (ladders)**
- **Fish passage at barriers (flow)**
- **Water temperature (flow and spring release)**
- CNFH Barrier Dam [*L*]
- Water quality
- Poaching
- Predation
- Competition
- Disease and other natural mortality factors

Factors Affecting Spawning and Incubation
- **Spawning habitat quantity (flow)**
- **Spawning habitat quality (sediment release)**
- **Redd dewatering (ramping rates)**
- **Water temperature (flow and spring release)**
- CNFH affects [*L*]
- Water quality
- Predation
- Disease and other natural mortality factors
- Exotic species invasions



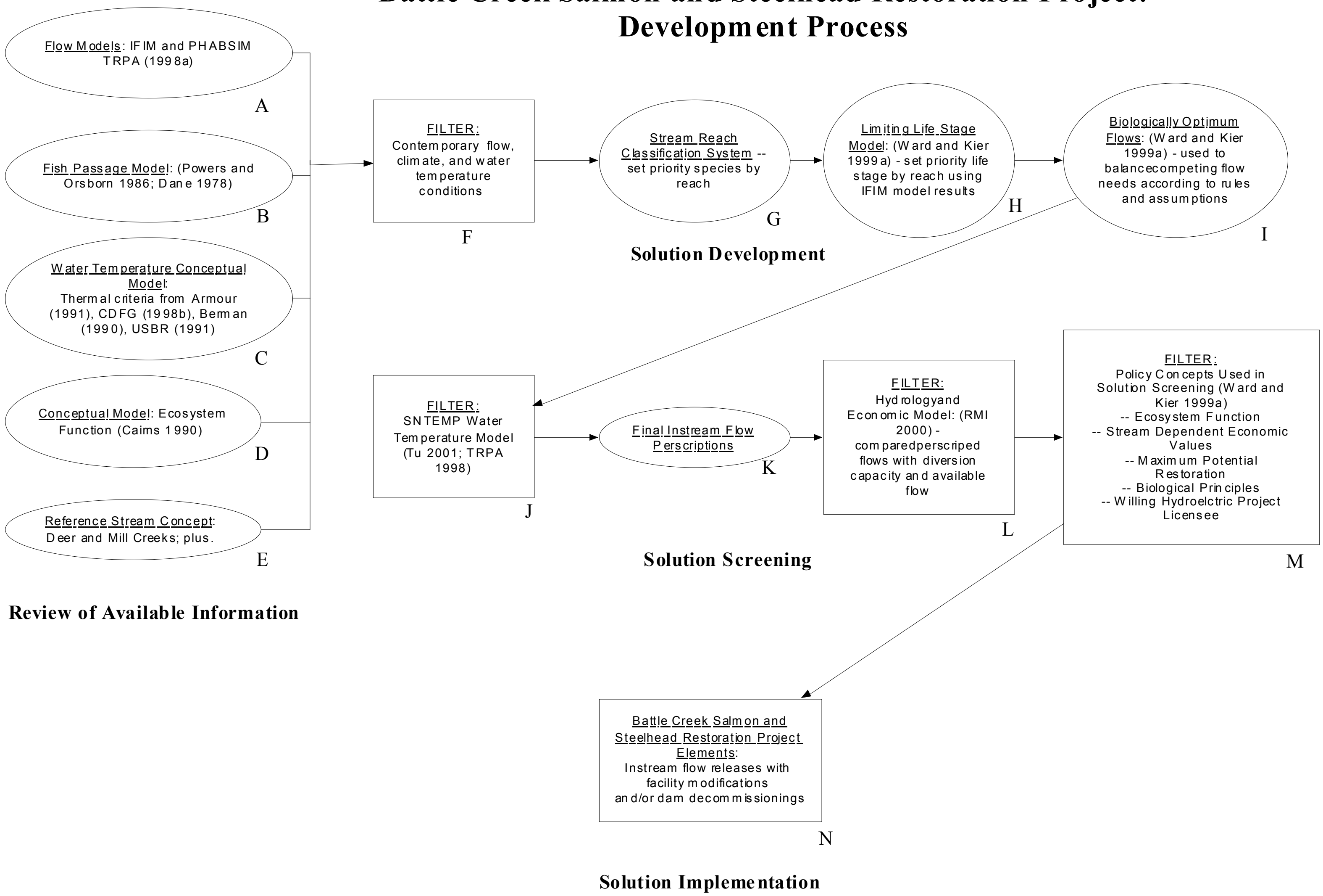
Factors Affecting Rearing
- **Rearing habitat quantity (flow)**
- **Stranding (ramping rates)**
- **Water temperature (flow and spring releases)**
- CNFH affects [*L*]
- Water quality
- Habitat quality
- Food and nutrient avaiability
- Predation
- Competition for resources other than space
- Disease and other natural mortality factors
- Exotic species invations

Factors Affecting Estuary and Ocean Rearing
- Harvest [*L*]
- Estuary and Ocean conditions

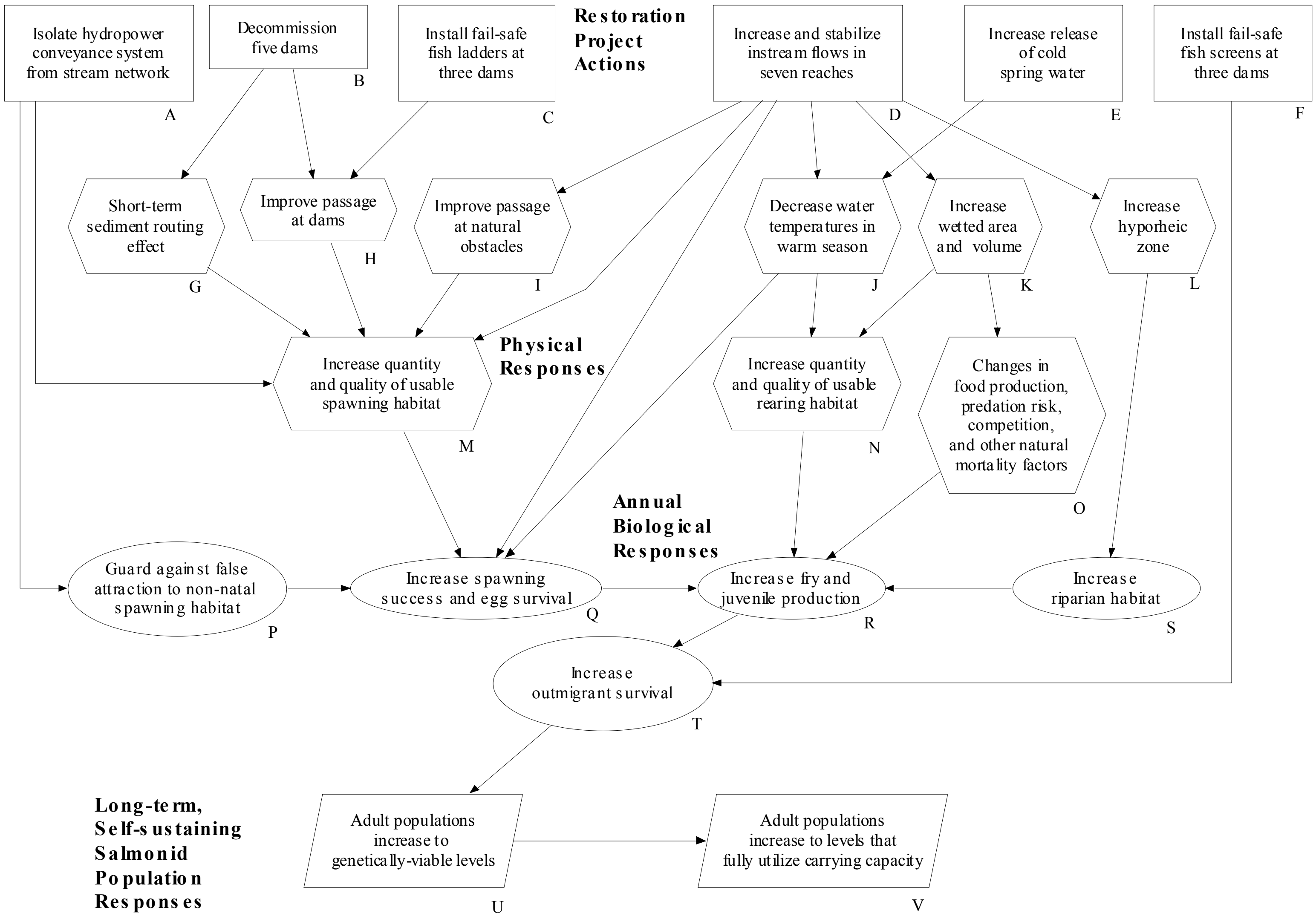
Factors Affecting Outmigration
- **Fish passage at diversion dams (screens)**
- **Water temperature (flow and spring release)**
- CNFH affects [*L*]
- Water quality
- Food and nutrient availability
- Predation
- Competition
- Disease and other natural mortality factors

Conceptual Model 1. Battle Creek limiting factors model with key uncertainties and key linkages.

Battle Creek Salmon and Steelhead Restoration Project: Development Process



Conceptual Model 2. Model illustrating the development of the Restoration Project including key passive adaptive management steps (e.g. review of available information, development of plausible solutions, and solution screening).



Conceptual Model 3. Restoration Project Implementation Model

I.D. Key Uncertainties and Learning Opportunities

The ecological dynamics of Battle Creek are not well understood despite the fact that many typical threats to salmonid populations are absent or are buffered within Battle Creek (as described in the Project Description). The following table lists many levels of uncertainties and is organized by uncertainties within 1) our understanding of factors limiting salmonid abundance in Battle Creek (Conceptual Model 1), 2) how the Restoration Project was developed (Conceptual Model 2), and 3) how implementation of the Restoration Project is expected to affect physical and biological processes (Conceptual Model 3).

These uncertainties range from basic scientific assumptions to questions about relationships within conceptual models to important unknowns in responses between biological processes and specific Restoration Project actions. We have used guidelines implicit in Healey's (2001) description of adaptive management to determine which of the many uncertainties are "Key Uncertainties."

We consider uncertainties to be "Key" if 1) the uncertainty has a high likelihood of affecting the success of the Restoration Project, and if 2) the uncertainty makes distinguishing between alternate adaptive responses difficult (Healey 2001). Furthermore, we use professional judgement to assess the quantity and quality of support within scientific literature for the assumptions that we use. That is, while all scientific understanding incorporates some level of uncertainty, the level of support for some scientific assumptions is sufficiently robust to suggest decreasing the emphasis on those uncertainties within this plan. Well supported assumptions which are not considered "key uncertainties" are included in this table to show readers that they were not overlooked.

For example, we are uncertain as to how thermal suitability criteria derived from the scientific literature for Sacramento River Chinook salmon apply to Battle Creek fish (Table 3). We do not consider this a "Key Uncertainty", however, because this assumption is robustly supported by existing literature and because variation in thermal suitability would likely be sufficiently low that this uncertainty is unlikely to have a large effect on the success of the Restoration Project or on our ability to distinguish between alternate adaptive responses.

Conversely, a "key uncertainty" includes the effects of increasing flows on fish passage at natural obstacles. If the assumption is wrong that prescribed minimum instream flows will provide adequate passage of adult salmon to preferred spawning habitat, this uncertainty has a high likelihood of affecting the success of the Restoration Project by lowering spawning success and population growth. In addition, the uncertainty of fish passage at natural obstacles makes distinguishing between alternate adaptive responses difficult. For example, a lack of adults reaching the preferred habitat because of fish passage problems at natural obstacles may be confounded with possible failures in the performance of fish ladders lower in the system, failures in North Fork production at earlier life stages, or factors from outside the watershed that limit the number of adults returning to Battle Creek.

Key Uncertainties are highlighted in **bold font** in Table 3. The comments explain: 1) why an uncertainty is not considered key or 2) tells how the Restoration Project addresses the uncertainty or why Restoration Project does not address the uncertainty. The column **"Model and Node"** allows the reader of Table 3 to visually place the uncertainty within the overall conceptual models by specifically referring to the appropriate conceptual model number and node letter.

Table 3. Uncertainties inherent in the Adaptive Management of Battle Creek Salmon and Steelhead Restoration Project. Use The column "Model and Node" to refer to the appropriate conceptual model number and node letter (Conceptual Models 1 – 3).

Factor	Model and Node	Uncertainty (Key uncertainties in bold)	Rationale and Implication of Uncertainty	Activity to Address Uncertainty	Objective/Study	Related Monitoring Task (Line number from Table 25)
Concept Models	1	**Factors identified as limiting, that will be addressed by the Restoration Project, may in fact not be limiting fish populations.**	Incorrect identification of limiting factors could undermine the foundation for the Restoration Project.	Implement AMP	AMP	all
Concept Models	1	**Factors identified as limiting may be insufficiently addressed by the Restoration Project or the other restoration/management activities described in the Linkages section of the AMP**	Incorrect identification of limiting factors could undermine the foundation for the Restoration Project.	Implement AMP	AMP	all
Concept Models	1	**Actual limiting factors in the Restoration Project Area may not have been identified and are not addressed by the Restoration Project.**	Incorrect identification of limiting factors could undermine the foundation for the Restoration Project.	Implement AMP	AMP	all
Concept Models	2E	**To what extend are habitat conditions, fish populations, and fish community structure in Reference Watersheds comparable to Battle Creek (especially if impaired passage at Red Bluff Diversion Dam is not remedied during the May 15 to Sept. 15 period in which the dam is operated)?**	Could jeopardize our ability to distinguish between alternate responses when interpreting adult population data. Variations in adult population levels may be difficult to interpret	Coordinate with monitoring programs in Reference Watersheds	none	none
Concept Models	2F	**To what extent do climate, flow, and temperature conditions in late 1990s, used in solution screening, compare with like conditions in 2006 to 2026?**	Changes in climate and hydrology could threaten the success of the Restoration Project.	Monitor hydrology and climate	Habitat Objective 2	10, 12
Concept Models	2G	**To what extent will steelhead and four runs of Chinook use the "A" and "B" grade habitats as predicted?**	Incorrect identification of suitable habitat could threaten the success of the Restoration Project.	Monitor habitat use and spawner distribution	Passage Objectives 1 and 3	2, 6, 7
Concept Models	2D	A restoration approach based on the concept of ecosystem function (Cairns 1990) may not adequately overcome the lack of a theoretical basis for predicting rates and pathways of recovery.	Not key because literature is robust in its criticism of single-species approach and support for ecosystem approach.	none	none	none
Concept Models	2G	Uncertainties are inherent in the use of professional judgement. To what extent did we get this right?	Not key because the use of professional judgement was minimized by the application of the scientific process and consensus-based application of knowledge.	none	none	none
Concept Models	2H	Steelhead limiting life stages were not identified.	Not key because "conservative, resource-protective interim flow standards" were used to set flow levels per (Castleberry et al. 1996).	none	none	none
Concept Models	2L	Effects of existing or future environmental regulation	Not key because Restoration Project removes the large amount of environmental liability associated with the existing project.	none	none	none

Factor	Model and Node	Uncertainty (Key uncertainties in bold)	Rationale and Implication of Uncertainty	Activity to Address Uncertainty	Objective/Study	Related Monitoring Task (Line number from Table 25)
Concept Models		Will monitoring activities and Focused Studies impact processes or limiting factors that could impede restoration of fish populations?	Not key because potential impacts that might be created by monitoring activities, if significant enough to threaten success of Restoration Project or confound distinction between project alternatives, would likely be large enough to trigger Adaptive Management responses.	none	none	none
Concept Models	3	The relative importance of various components of the Restoration Project is unknown (Healey 2001).	Not key because, if other assumptions hold true, cumulative effects of all actions should generate success regardless of relative importance of individual components and because key uncertainties that could hinder our ability to distinguish among alternate responses are individually addressed (see the rest of this table).	none	none	none
Passage/Barriers	2B	**Uncertainties are inherent in fish passage/barrier models (Powers and Orsborn 1986; Dane 1978).**	In adequate model predictions resulting in inadequate fish passage could threaten the ability of spawners to reach suitable habitat.	Monitoring may suggest need to rely on updated models.	Passage Objective 3	7g, 24
Passage/Barriers	2B	**Results of 1989 field studies may not apply to conditions occurring during the term of the Restoration Project (between 2006 and 2026).**	Changing field conditions could confound identification of potential spawner distribution problems. Inadequate fish passage could threaten the ability of spawners to reach suitable habitat.	Potential barriers will be assessed in the course of annual surveys	Passage Objective 3	7f
Passage/Barriers	3D-3I	**Will new instream flows provide fish passage at natural obstacles that meets the level predicted using Powers and Orsborn methodology and will that level of passage meet or exceed that required for fish ladders?**	In adequate model predictions resulting in inadequate fish passage could threaten the ability of spawners to reach suitable habitat.	A Diagnostic radiotelemetry study will be performed. Potential barriers will be assessed in the course of annual surveys. Fish distribution will be closely examined.	Passage Objective 3	7g
Passage/Barriers	2B	The spatial and temporal dynamics of flow/barrier relationships are not well understood.	Uncertainty at this scale is unlikely to affect project success or ability to distinguish between alternatives because monitoring in Passage Objective 3 is designed to detect any adverse, larger-scale signals.	Contemporary advancements in fish passage models will be employed.	Focused Studies	24
Passage/Dams	3C-3H	**Will Fail-Safe Fish Ladders insure adequate upstream passage at dams?**	All adults are exposed to fish ladders and their potential problems; passage problems at ladders could affect entire population.	A Diagnostic radiotelemetry study will be performed. Monitor fish passage at dams; monitor performance of ladders	Passage Objective 1	2, 7

Factor	Model and Node	Uncertainty (Key uncertainties in bold)	Rationale and Implication of Uncertainty	Activity to Address Uncertainty	Objective/Study	Related Monitoring Task (Line number from Table 25)
Passage/Dams	3F-3T	Will Fail-Safe Fish Screens insure adequate downstream passage of juveniles at dams?	Only a portion of juvenile population may be exposed to fish screens. Not key because literature on this topic is generally accepted and robust. Fish screening has repeatedly been shown to improve outmigrant survival to adequate levels as defined in MOU.	Monitor performance of screens, check for possible entrainment.	Passage Objective 2	17, 18, 19,,
False Attraction	3A-3P	**Will facility modifications sufficiently isolate hydropower conveyance system from stream network to guard against false attraction?**	Continued discharges of North Fork water to the South Fork could attract spawning salmonids to unsuitable habitat, and away from suitable habitat, thereby reducing spawning success and egg survival.	Look for salmonid response to leakage or discharges; analyze discharges.	Habitat Objective 3	7c, 9a, 9b
Spawning	3D-3M	**Will new instream flows increase the quantity and quality of usable spawning and rearing habitat?**	If habitat quantity or quality does not respond positively to increased instream flows then anticipated population growth may not occur.	Monitor habitat use and quantity	Habitat Objective 1	7b
Spawning	3H-3M	**How will spawning activity be distributed within the restored habitat that is made accessible by Fail-Safe Fish Ladders?**	Chinook races could hybridize; production could be limited if adults can't reach best habitat.	Determine spawning distribution of various races.	Passage Objective 1	2, 7g
Spawning	3I-3M	**How will spawning activity be distributed within the restored habitat that is made accessible by reducing natural obstacles with higher instream flows?**	Chinook races could hybridize; production could be limited if adults can't reach best habitat.	Determine spawning distribution of various races.	Passage Objective 3	2, 7g
Spawning	3P-3Q	**Will measures taken to guard against false attraction be sufficient for attaining the conservation goals for target species by assuring fidelity of returning spawners to suitable habitat?**	If these measures are insufficient then the ability to distinguish between alternative responses may be confounded and populations may not grow as anticipated.	Monitor fish response to leakages and discharges	Habitat Objective 3	7c, 9a, 9b
Spawning	3G-3M	**Will there be measurable effects on the quantity, quality, and use of spawning and rearing habitat caused by the amount of fine sediment discharged from dam removal, road building and instream construction activities?**	Sediment movement is difficult to predict and problems could arise (e.g. pool filling, fine sediment infiltration of gravels). Mitigation requirements (e.g. waste discharge permit will likely require excavation of stored sediment, erosion control, and construction timing) and small volume of sediment affected (5,000 cu. yd. on North Fork and 58,000 cu. yd. on South Fork) will likely minimize duration and magnitude of effects. Excavated sediments will be placed on high-flow terraces. May affect estimates of carrying capacity and juvenile production during initial years post construction.	Assess sediment dynamics and associated channel morphological responses; validate existing fractional sediment routing models.	Focused Study	22
Spawning	3M-3Q	**How will post-project spawning success and egg survival be affected by increased quantity, quality, and use of spawning habitat?**	If spawning success or egg survival does not respond to improved spawning habitat then populations will not grow as anticipated.	Monitor fry and juvenile production	Population Objective 1	4,5, 7a

Factor	Model and Node	Uncertainty (Key uncertainties in bold)	Rationale and Implication of Uncertainty	Activity to Address Uncertainty	Objective/Study	Related Monitoring Task (Line number from Table 25)
Spawning	2G	**Uncertainties are inherent in the estimate of the amount of available spawning habitat. These surveys were done at flows of 3 and 5 cfs by visual estimation of wetted perimeter at an unspecified higher flow (Kondolf 1989). Also, gravel mining at Inskip Reservoir was practiced at the time of the survey.**	If habitat quantity or quality does not respond positively to increased instream flows then anticipated population growth may not occur.	Update estimate of spawning habitat under the initial flow regime after the course sediment delivered from dam removals reaches equilibrium in the system.	Population Objective 1	29
Spawning	2H	**Uncertainties inherent in estimates of redd area and utilization of available spawning habitat.**	Estimates of redd area, including defense area, were derived from studies of other Central Valley stocks. May affect estimates of carrying capacity and juvenile production.	Carcass and redd distribution surveys; update estimates of redd area using Contemporary information; juvenile production estimates.	Population Objectives 1,2, and 3	7b
Spawning	2H	**Uncertainties inherent in estimates of spawner to fry survival and in estimates of number of fry produced per WUA.**	Estimates were based upon upper Sacramento River studies in 1980's and prior (Hallock 1986). Newer modeling efforts are currently taking place on upper Sacramento and Trinity Rivers which may prove useful.	Update using Contemporary information available from Focused Studies in Battle Creek.	Focused Study; the Life History Focused Study will address spawner-to-fry survival indirectly in the examination of spawner-to-juvenile survival.	25, 28,
Spawning	2H	**Uncertainties inherent in estimates of spawner to juvenile in estimates of number of juveniles produced per WUA.**	Estimates were based upon upper Sacramento River studies in 1980's and prior (Hallock 1986). Newer modeling efforts are currently taking place on upper Sacramento and Trinity Rivers which may prove useful.	Update using Contemporary information available from Focused Studies in Battle Creek.	Focused Study	4a, 4b, 23, 26
Spawning	2H	Uncertainties inherent in estimates of female fecundity.	Deviation from literature predictions likely to be small and have small effect.	none	none	none
Rearing	3K-3O	**Food production, predation risk, growth, competition, disease, and other factors of natural mortality**	Low juvenile production threatens project success. Predictions of distribution and estimates of carrying capacity may be confounded.	Temperature monitoring on key reaches, outmigrant trapping at forks; observe condition factor of outmigrants	Habitat Objective 2 and Population Objective 1	4, 5, 11, 11b

Factor	Model and Node	Uncertainty (Key uncertainties in bold)	Rationale and Implication of Uncertainty	Activity to Address Uncertainty	Objective/Study	Related Monitoring Task (Line number from Table 25)
Rearing	3K-3O	Do changes in natural mortality factors occur in response to increased wetted area and volume?	Not key because, if assumptions of ecosystem function hold true, these factors likely to improve with restoration of ecosystem process and therefore are unlikely to affect the success of Restoration Project. Measures of these factors generally are insufficiently powerful to help distinguish between alternative responses.	none	none	none
Stranding and Isolation	3D-3Q	Will Ramping Rates initiated at designated threshold flows be sufficient to prevent significant stranding and isolation of juvenile salmon and steelhead in each of the forks?	Biologically significant salmon or steelhead stranding or isolation could occur but this is not considered a key uncertainty because threshold flow was determined at the site most susceptible to stranding in the entire Project Area; conservative methods were used for determining Ramping Rates; ramping will only occur infrequent as this hydroelectric project is not a peaking project.	Collect evidence of fish stranding during the course of other monitoring studies. The risk of this uncertainty does not warrant the design of specific studies prior to Restoration Project implementation..	Habitat Objective 4	7c
Physical Habitat	3B-3G	What will be the long-term effects of dam decommissioning on channel stability?	Not key because dams are built on stable bedrock; any channel responses are unlikely to be large enough to have a measurable effect.	Assess sediment dynamics and associated channel morphological responses; validate existing fractional sediment routing models.	Focused Study	22
Physical Habitat	3B-3H	Will upstream/downstream fish passage at former dam sites meet the level of unimpaired passage expected under the Restoration Project for Fail-Safe Fish Ladders?	Not key because possible disruptions of fish passage from remaining reservoir sediments are likely to be small and of short duration, due to mitigation measures and the relatively small quantities of accumulated sediments.	Closely monitor mitigation measures; remove sediment from active channel if necessary.	Passage Objective 3	7, 7g, 22, 24
Physical Habitat	3D-3L	Will new instream flows increase the extent of the hyporheic zone thereby increasing riparian habitat?	Expected changes unlikely to affect success of Restoration Project. This is not a powerful metric for distinguishing between alternative responses. Monitoring is needed for assessing construction-mitigation to riparian habitat.	Study changes in extend of riparian habitat related to changes in hyporheic zone..	Focused Study	23

Factor	Model and Node	Uncertainty (Key uncertainties in bold)	Rationale and Implication of Uncertainty	Activity to Address Uncertainty	Objective/Study	Related Monitoring Task (Line number from Table 25)
Physical Habitat	2A	**Uncertainties are inherent in the IFIM and PHABSIM models (Instream Flow Council (2002 and Castleberry 1996) including: 1) sampling and measurement problems associated with representing 42 miles of stream; 2) sampling and measurement problems associated with developing habitat suitability curves; and 3) problems with assigning biological meaning to weighted usable area; especially without presenting confidence intervals.**	Non-optimal habitat quantity from inappropriate instream flows could delay population growth and could confound interpretation of other data. Restoration Project instream flows may be thought of as experimental although the scope of the experiment cannot be negotiated at present. For example, the AMP expires in 2026 when the flow schedules may be subjected to revision at the time of relicensing. Analysis of alternative flow regimes and negotiations in preparation of the relicensing activity may begin as soon as 15 years after the Restoration Project's currently scheduled completion date.	Apply advancements in science or modeling, apply Water Acquisition Fund	Habitat Objective 1	25
Physical Habitat	2A	**Habitat suitability criteria curves developed in 1989 in TRPA 1998a, which were based on studies outside of the Restoration Project Area and were applied to the three species targeted by the Restoration Project, may not be completely appropriate to each of the target species.**	Non-optimal habitat quantity from inappropriate instream flows derived from flawed data/models could delay population growth and could confound interpretation of other data.	Collect habitat suitability data from reference populations if warranted	Habitat Objective 1	7b, 20, 25
Physical Habitat	2A	Predicted effects of instream flow on the physical characteristics of wetted area, depth, velocity, and cover may not adequately characterize the actual conditions in the 42 miles of habitat	Not key because the physical relationships between increase flow and changes in depth and velocity (if not cover) are generally accepted and robust (e.g. Leopold, Wolman, and Miller 1992).	Compare methods used in 1989 with current methods to gage uncertainty	Habitat Objective 1	25
Physical Habitat	2I	Did Restoration Project instream flows achieve a proper balance between the competing needs of various life-stage/species combinations?	Not key because "conservative, resource-protective interim flow standards" were used to set flow levels per (Castleberry et al. 1996) if other assumptions hold true.	Apply advancements in science or models	Habitat Objective 1	25
Physical Habitat	2I	Was the target of achieving 95 percent of maximum WUA appropriate for the Adaptive Management approach?	Not key because "conservative, resource-protective interim flow standards" were used to set flow levels per (Castleberry et al. 1996) if other assumptions hold true. Restoration Project flows can be viewed as "experimental" in that they may only be in place between 2006 (expected completion date of Restoration Project) and 2026 (when the FERC license is renewed and new flow regime may be implemented).	Apply advancements in science or models	Habitat Objective 1	25
Physical Habitat	2I	Daily flows and unusually high flows are believed to be the major flow-related factors limiting production..	Not key, if assumptions of ecosystem function and assumptions in daily instream flow uncertainties hold true. High flows are unlikely to affect success of Restoration Project because fish populations have evolved to accommodate the natural flow regime. Only daily flows can be controlled below dams. Unusually high-flows events will continue to occur and are natural, uncontrollable events which may affect fish production by scouring redds or limiting rearing habitat.	If anticipated production levels are not observed, examine hydrograph for unusually high runoff events with possible deleterious effects.	Population Objective 1	4a

Factor	Model and Node	Uncertainty (Key uncertainties in bold)	Rationale and Implication of Uncertainty	Activity to Address Uncertainty	Objective/Study	Related Monitoring Task (Line number from Table 25)
Physical Habitat	2I	Catastrophic effects of floods on available fish habitat and fish populations cannot be anticipated or controlled.	Project success is measured over multi-year scale to account for annual variation in production. Year classes could be lost or long-term habitat effects could occur.	Compare generally with Reference Watersheds to estimate the magnitude of effect.	Population Objective 1	4a
Physical Habitat	2I	What hydrologic effect does the hydroelectric project have on channel forming processes?	The effect is probably not measurable because the project does not include enough storage to effect seasonal changes in the hydrograph and because channel forming flows are much greater than the diversion capacity of the project.	Directly observe the effects of channel forming flows on reservoir sediment.	Focused Study	22
Physical Habitat	2A	Estimated instream flow requirements Baldwin Creek below Asbury Dam were based upon simple visual observations of wetted perimeter and release of spring water for coldwater refuges without development in a formal study.	Not key because the amount of habitat is extremely small (0.75 miles) relative to the overall project. Minor, likely unmeasureable effect on watershed-scale steelhead production.	Possible flow experimentation.	none	none
Physical Habitat	2I	Are Keswick Reach inflows and accretion adequate to provide predicted WUA in lower Keswick reach?	Limited habitat in this reach unlikely to affect success of Restoration Project on steelhead or Chinook restoration. Minor effect on steelhead production	none	none	none
Physical Habitat	2L	**Does the hydrology model adequately predict available flow and diversion capacity for both instream and hydro uses under different water year types?**	Viable hydroelectric project success criteria may not be met due to this uncertainty.	Post project flow monitoring will be used to validate models; Monitor climate.	Habitat Objective 1; Habitat Objective 2	9, 15
Physical Habitat	2L	**Effects of possible climate change on hydrology**	Currently not predictable but possibly significant.	Climate and hydrology will be monitored throughout the region.	Habitat Objective 1; Habitat Objective 2	9, 12
Water Temp.	2J	**Uncertainties are inherent in SNTEMP and other water temperature models.**	Invalid model predictions could confound habitat suitability predictions. Estimates of carrying capacity may be confounded.	Temperature monitoring on key reaches.	Habitat Objective 2	11, 11a, 11b
Water Temp.	2J	**Uncertainties are inherent Tu's (2001) application of the SNTEMP model in Battle Creek (e.g. is Redding climate data applicable to Battle Creek? What are the effects of canals and shading on thermal gain? Will potential temperature problems be restricted to June through September?)**	Invalid model predictions could confound habitat suitability predictions. Estimates of carrying capacity may be confounded.	Temperature monitoring on key reaches.	Habitat Objective 2	11, 11a, 11b, 12, 13
Water Temp.	3D-3J	**Will post project instream flow releases result in predicted water temperatures targets in warm season?**	Invalid model predictions could confound habitat suitability predictions. Estimates of carrying capacity may be confounded.	Temperature monitoring on key reaches.	Habitat Objective 2	11, 11a, 11b
Water Temp.	3E-3J	**Will post project release of cold spring water result in predicted water temperatures targets in warm season?**	Invalid model predictions could confound habitat suitability predictions. Estimates of carrying capacity may be confounded..	Temperature monitoring on key reaches.	Habitat Objective 2	11, 11a, 11b

Factor	Model and Node	Uncertainty (Key uncertainties in bold)	Rationale and Implication of Uncertainty	Activity to Address Uncertainty	Objective/Study	Related Monitoring Task (Line number from Table 25)
Water Temp.	3E-3J	**How are cooling effects of spring releases spatially distributed within stream network?**	Distribution of temperature-sensitive life stages may be affected confounding habitat suitability predictions. Predictions of distribution and estimates of carrying capacity may be confounded.	Document the extant and distribution of cold-water refuges that develop from the release of Eagle Canyon Springs and Bluff Spring waters	Focused Study	11a, 27
Water Temp.	3E-3J, 2C	**Are there microhabitat benefits (thermal refuges) that could result from spring releases that were overlooked by reach-scale water temperature models such as SNTEMP?**	Unanticipated use of thermal refuges would improve chance for project success. Predictions of distribution and estimates of carrying capacity may be confounded.	Document fish use of cold-water refuges that develop from the release of Eagle Canyon Springs and Bluff Spring waters	Focused Study	27, 28
Water Temp.	3Q, 3N	**How will spawning success and egg survival be affected by water temperature regime in warm season?**	Low spawning success and egg survival threaten project success. Predictions of distribution and estimates of carrying capacity may be confounded.	Temperature monitoring on key reaches, calculate predicted embryo survival based on observed temperature regime.	Habitat Objective 2	5, 6, 7a, 11, 11a, 11b
Water Temp.	3J-3Q, 2C	**How will juvenile production (growth, survival, distribution, outmigration) be affected by water temperature regime in warm season?**	Low juvenile production threatens project success. Predictions of distribution and estimates of carrying capacity may be confounded.	Temperature monitoring on key reaches, outmigrant trapping at forks; observe condition factor of outmigrants	Habitat Objective 2 and Population Objective 1	4, 5, 7a, 11, 11a, 11b
Water Temp.	2C	Are literature-derived thermal suitability criteria applicable to Battle Creek fish?	Not key because literature is robust and was developed for the same stocks of fish likely to colonize this stream from nearby habitats. Estimates of carrying capacity may be confounded.	Consider Focused Studies based on Contemporary information from Focused Studies in Battle Creek.	Habitat Objective 2	25, 28
Population Dynamics	2H	**IFIM results (WUA curves) cannot be confidently converted to estimates of fish production without validating the 1989 IFIM model for Battle Creek salmon and steelhead (e.g. establishing confidence limits and examining transects for significant changes in channel morphology and applying more appropriate habitat suitability curves, etc).**	Efforts may include, 1) post project reconnaissance level survey of PHABSIM transects to examine changes in channel morphology over the last 20 years, 2) compare the habitat suitability curves used in the IFIM study to those currently available for target species for current applicability	Establish validity of the model	Habitat Objective 1; Population Objective 1	7b, 7i, 25, 27

Factor	Model and Node	Uncertainty (Key uncertainties in bold)	Rationale and Implication of Uncertainty	Activity to Address Uncertainty	Objective/Study	Related Monitoring Task (Line number from Table 25)
Population Dynamics	3Q-3R	**Will fry and juvenile production be improved by increased spawning success and egg survival?**	If fry and juvenile production does not respond to improved spawning success and egg survival then populations will not grow as anticipated.	Monitor fry and juvenile production	Population Objective 1	4, 5
Population Dynamics	3N-3R	**Will fry and juvenile production be improved by increased usable rearing habitat?**	If fry and juvenile production does not respond to increased rearing habitat then populations will not grow as anticipated.	Monitor fry and juvenile production	Population Objective 1	4, 5
Population Dynamics	3O-3R	Will fry and juvenile production be improved by improvements in natural mortality factors?	Not key because, if assumptions of ecosystem function hold true, these factors are likely to improve with restoration of ecosystem process and therefore are unlikely to affect the success of Restoration Project. Measures of these factors generally are insufficiently powerful to help distinguish between alternative responses.	none	none	none
Population Dynamics	3S-3R	Will fry and juvenile production be improved by improvements in riparian habitat?	Not key because unlikely to affect success of Restoration Project and not a powerful metric for distinguishing between alternative responses	none	none	none
Population Dynamics	3R-3T	**Will the number of surviving outmigrant steelhead and Chinook salmon increase as a result of improvements in fry and juvenile production?**	If outmigrant production does not respond to improved fry and juvenile production then populations will not grow as anticipated.	Monitor outmigrant production	Population Objective 1	4, 5
Population Dynamics	3R-3T	**Run-specific identification of juvenile salmon is presently based on length-at-age data developed outside of Battle Creek and may not apply.**	The current methods for determining run designation for out migrating juvenile salmon is based on size criteria based on studies in the main stem Sacramento River by Fisher in 1991. These size criteria may not be appropriate for use in tributaries of the Sacramento River and could confound estimates of juvenile production by run.	Monitor outmigrant production with downstream migrant traps and complete genetic testing on juveniles of known size	Part of Life History Focused Study	28
Population Dynamics	3M	**Will there be density-dependent competition relating to spatial and temporal overlap of different runs of Chinook salmon?**	Density-dependent effects (e.g. competition for spawning or rearing habitat) could impede anticipated population growth.	Estimate carrying capacity.	Population Objective 1	7, 28
Population Dynamics	3T	Will the estimated number of outmigrant salmon be within the range of what is predicted from the estimated number of spawners based upon the commonly accepted survival rates from spawning to outmigration?	Not key because estimates of fecundity are based on robust literature and because spawning success and fry/juvenile production are monitored under other uncertainties.	none	none	none
Population Dynamics	3U	The scientific definition of genetically viable population levels is tentative or vague.	Not key because the best available science suggests that sufficient habitat exists to support even the most conservative genetically viable population levels. Viable population levels are likely to be low enough to not influence the success of project. The science used to generate actual estimates of genetically viable populations levels is sufficiently vague to not be helpful in distinguishing between alternative responses. Achievement of numerical targets may not mean that genetic considerations have been met.	Encourage Technical Review Team to complete research into viable population levels for Battle Creek.	none	none

Factor	Model and Node	Uncertainty (Key uncertainties in bold)	Rationale and Implication of Uncertainty	Activity to Address Uncertainty	Objective/Study	Related Monitoring Task (Line number from Table 25)
Population Dynamics	3U	**Will variability in adult population levels correlate with outmigrant abundance?**	Limiting factors outside of the Project Area could confound the ability to distinguish among Adaptive Management responses and could threaten the success of the project.	Compare population growth with Reference Watersheds when information is available.	Population Objectives 2 and 3	1a, 1b, 1c
Population Dynamics	3V	**What is the carrying capacity of Battle Creek for each salmonid stock?**	Unknown carrying capacity confounds measure of success.	Define the carrying capacity of each species	Population Objectives 3	1, 1d
Population Dynamics	3V	**How will carrying capacity estimates vary over time?**	Unknown carrying capacity confounds measure of success.	Define the carrying capacity of each species including variability	Population Objectives 3	1, 1a-c, 4, 4a, 6
Population Dynamics	3V	**How can we tell when fish populations are fully utilizing carrying capacity?**	Unknown carrying capacity confounds measure of success.	Apply advancements in population ecology	Population Objectives 3	1, 1a-d, 4, 4a
Population Dynamics	n.a.	**What will be the response of the fish community structure (including non-salmonids) within Battle Creek as a result of project implementation?**	The AMPT proposes this study in light of the recognition that other ecosystem values may be affected, beyond salmonids and beyond other fish populations. This proposed study of changes in fish community structure is an attempt to balance between a narrow focus on salmonids and the broader suite of ecosystem implications not already covered in Linkages. Other ecosystem values may be affected	Study changes in distribution of fish before and after Restoration Project implementation	Focused Study	21
Project success is measured in economic as well as biological terms. This table attempts to capture economic uncertainties that exist within the Restoration Project. However, the reader should recognize that the this table was prepared by biologists who may be unqualified to perform detailed economic analyses.						
Economics	2L	**Are diversions that are not decommissioned going to be economically viable?**	Viable hydroelectric project success criteria may not be met due to this uncertainty. Future decision-making may need to consider cost-effectiveness.	Licensee to monitor economic viability.	none	none
Economics	2L	**Are upgrades to dams that are not decommissioned cost effective?**	Not related to a measure of Restoration Project success though may be useful in distinguishing between alternative responses. Future decision-making may need to consider cost-effectiveness.	AMP/MOU/FERC protocols shape decision making process related to possible future dam modifications	none	none

Factor	Model and Node	Uncertainty (Key uncertainties in bold)	Rationale and Implication of Uncertainty	Activity to Address Uncertainty	Objective/Study	Related Monitoring Task (Line number from Table 25)
Economics	2L	**Prediction of future climate as it affects hydrology and hydro production with Restoration Project**	Viable hydroelectric project success criteria may not be met due to this uncertainty. Future decision-making may need to consider cost-effectiveness.	Hydrology will be monitored throughout the region	none	none
Economics	2L	**Prediction of future price structures for electric energy with Restoration Project**	Viable hydroelectric project success criteria may not be met due to this uncertainty. Future decision-making may need to consider cost-effectiveness.	Licensee to monitor economic viability.	none	none
Economics	3D-3Q	Will Ramping Rates achieve the best compromise between stranding and economics?	Not key because ramping is so infrequent that it is not a significant economic driver of the Battle Creek Hydroelectric Project. Overly conservative Ramping Rates could reduce hydroelectric project generation.	none planned	Habitat Objective 4	none

I.E. Goals and Objectives Summary

The primary goal of the Restoration Project is to restore and enhance approximately 42 miles of anadromous fish habitat in Battle Creek and an additional 6 miles of habitat in its tributaries while minimizing the loss of renewable energy produced by the Battle Creek Hydroelectric Project (FERC Project No. 1121). The additional 48 miles of anadromous fish habitat is being restored to support an assemblage of fish species including four separate runs (races)[4] of Chinook salmon and steelhead. The four runs of Chinook salmon include winter-run, spring-run, fall-run and late fall-run. Winter-run Chinook, spring-run Chinook, and steelhead have been identified as the priority species for recovery because they are listed under the state or federal endangered species act (CESA and ESA respectively) as either endangered (winter-run Chinook) or threatened (spring-run Chinook and steelhead. Fall-run Chinook and late fall-run Chinook are also included in the restoration goals for Battle Creek and are listed as candidate species under the ESA. Restoration of fall-run Chinook and late fall-run Chinook salmon may be delayed until viable population levels have been met for higher priority salmonids. This delay may occur if the restoration of fall-run Chinook and late-fall run Chinook salmon would impede the ability of higher priority species to achieve viable population levels. Restoration of fall-run Chinook and late fall-run Chinook salmon could only be further delayed or interrupted after the higher priority species have achieved viable population levels if it is demonstrated that their restoration impedes the ability these species to maintain viable population levels and if no other Adaptive Management actions can be taken to assist the higher priority species.

The objectives of the Restoration Project include: (1) restoration of self-sustaining populations of four races of Chinook salmon and steelhead, and their habitats in the Battle Creek watershed through a voluntary partnership with state and federal agencies, a third party donor(s), and PG&E; (2) up-front certainty regarding specific restoration components, including Resource Agency prescribed instream flow releases, selected decommissioning of dams at key locations in the watershed, dedication of water diversion rights for instream purposes at decommissioned sites, construction of tailrace connectors, and installation of Fail-Safe Fish Screens and Fail-Safe Fish Ladders; (3) timely implementation and completion of restoration activities, and; (4) joint development and implementation of a long-term AMP with dedicated funding sources to ensure the continued success of restoration efforts under this partnership.

[4] The scientific use of the terms “runs” and “races” can be confusing, and may be confounded in this document. “Race” is most properly used to describe component populations of the same species which are genetically distinguishable. “Run” is more generally used to describe component populations of the same species that migrate and spawn at different times or locations. While some runs in Battle Creek have been shown to be properly considered races, additional genetics work remains before all four runs can be properly considered as races. In this document, we attempt to adhere to these conventions and try to use “race” in its genetic context. Errors in usage may arise where it was important to use the genetic connotation in a reference to the four runs even though it has not been proven that indeed four races exist.

I.F. Document History and Purpose

In June 1999, PG&E, NOAA Fisheries, CDFG, U.S. Fish and Wildlife Service (USFWS), and U.S. Bureau of Reclamation (USBR) entered into a MOU that signaled the intent of these MOU Parties to pursue a salmon and steelhead restoration effort on Battle Creek that would modify the facilities and operations of PG&E's Battle Creek Hydroelectric Project (FERC Project No. 1121). Consequently, a federal-state interagency program known as the CALFED provided $28 million in directed funding for the planning and implementation commitments of the Resource Agencies' portions of any approved project elements resulting from the proposed Battle Creek Salmon and Steelhead Restoration Project (Restoration Project).[5]

The MOU Parties agreed that Adaptive Management is an integral component of the Restoration Project. Adaptive Management is a process that (1) uses monitoring and research to identify and define problems; (2) examines various alternative strategies and actions for meeting measurable biological goals and objectives; and (3) if necessary, makes timely adjustments to strategies and actions based upon best scientific and commercial information available.[6]

The primary reason for using an Adaptive Management process is to allow for changes in the restoration strategies or actions that may be necessary to achieve the long-term goals or biological objectives of the Restoration Project and to ensure the likelihood of the survival and recovery of naturally spawning Chinook salmon and steelhead. Using Adaptive Management, restoration activities conducted under the Restoration Project will be monitored and analyzed to determine if they are producing the desired results (i.e., properly functioning habitats).[6]

To formalize the use of Adaptive Management in the Restoration Project, an AMP was developed by the PG&E, NOAA Fisheries, USFWS, and CDFG (collectively known herein as "Parties"). Biological goals are the broad guiding principles for the AMP and are the rationale behind the minimization and mitigation strategies or actions. Specific biological objectives are the measurable targets for achieving the biological goals. The goal of the AMP is to implement specific actions to protect, restore, enhance, and monitor salmonid habitat at FERC Project No. 1121 to guard against false attraction of adult migrants and ensure that Chinook salmon and steelhead are able to fully access and utilize available habitat in a manner that benefits all life stages and thereby maximizes natural production, fully utilizing ecosystem carrying capacity.[7]

As implementation of the Restoration Project proceeds, results will be monitored and assessed. If the anticipated goals and objectives are not being achieved, adjustments in the restoration strategy or actions will be considered through the AMP, which has been developed consistent with the relevant CALFED guidelines. A Water Acquisition Fund (WAF), AMF, and Licensee Commitment are elements of Adaptive Management which will provide funding for potential changes to Restoration Project actions that result from application of the AMP.[6]

---

5 Notice Of Preparation Project Background
6 MOU 9.0
7 MOU 9.1.A.2.(a). Ecosystem carrying capacity is not specifically defined in the MOU or AMP. Rather, the use of that term in this document conforms to the sense of the definition of "maximum carrying capacity" in Odum (1983), which says that theoretical maximum carrying capacity is reached when no further increase in the size of a population occurs because maintenance energy costs balance available energy.

The AMP will be submitted by PG&E to the FERC at the time that PG&E files its license amendment application pursuant to the MOU. The Parties acknowledge that implementation of the AMP could later involve proposals for changes in operations, project facilities, and possible decommissioning of some additional FERC Project No. 1121 facilities to improve biological effectiveness and habitat values for Chinook salmon or steelhead.[8]

The AMP is designed to be consistent with and fulfill the goals and objectives of the Restoration Project. The primary goal of the Restoration Project is to restore and enhance approximately 42 miles of anadromous fish habitat in Battle Creek plus an additional 6 miles of habitat in its tributaries while minimizing the loss of clean (emission-free), renewable energy produced by the Battle Creek Hydroelectric Project. The primary objective of the Restoration Project is to provide increased habitat and reliable upstream and downstream migration routes for salmonids. Reliable migration routes for salmonids refers not only to safe passage but also includes measures that allow returning adult salmonids to find their natal streams by minimizing the false attraction of North Fork fish to the South Fork of Battle Creek. Current hydroelectric project operations result in transfer of most of the natural flow of the North Fork to the South Fork, which could cause false attraction of returning adult migrants born in the North Fork to the South Fork.

The MOU described the following goals, or benefits, of the Restoration Project: restoration of self-sustaining populations of Chinook salmon and steelhead and their habitat in the Battle Creek watershed through a voluntary partnership with state and federal agencies, the Packard Foundation, and PG&E;[9] up-front certainty regarding specific restoration components;[10] timely implementation and completion of restoration activities;[11] and joint development and implementation of a long-term Adaptive Management Plan with dedicated funding sources to ensure the continued success of restoration efforts under this partnership.[12] Furthermore, implementation of the Restoration Project will be consistent with the following restoration directives and programs:

- Central Valley Project Improvement Act (CVPIA; Public Law 102-575 Section 3401 et seq.) Anadromous Fish Restoration Program (AFRP);
- State Salmon, Steelhead Trout, and Anadromous Fisheries Program Act (State Senate Bill 2261, 1990) Central Valley Salmon and Steelhead Restoration and Enhancement Plan;
- NOAA Fisheries Recovery Plan for Sacramento River Winter-run Chinook Salmon;
- CALFED Ecosystem Restoration Program;
- Upper Sacramento River Fisheries and Riparian Habitat Management Plan (State Senate Bill 1086, 1989);
- Restoring Central Valley Streams- A Plan for Action (1993); and
- Steelhead Restoration and Management Plan for California (1996).[13]

[8] MOU 9.1
[9] MOU 1.4.A
[10] MOU 1.4.B
[11] MOU 1.4.C
[12] MOU 1.4.D
[13] MOU 1.7

I.G. Document Organization

This document was written to provide a complete understanding of the Adaptive Management process as applied to the Battle Creek Salmon and Steelhead Restoration Project, and to serve as a procedural and planning reference tool for Contemporary managers of the Restoration Project and Battle Creek fisheries. However, it was not written to be a "stand alone" document in that it does not include all background and reference documentation (Table 4); rather, it depends directly on key supporting documents including, primarily, the Battle Creek Salmon and Steelhead Restoration Plan (Restoration Plan), the CALFED Ecosystem Restoration Plan (CALFED 1999), and the Facility Monitoring Plan which is currently being prepared per the MOU for matters of regulatory compliance. Users of this document who are interested in learning more about the foundation of the Restoration Project and related actions, the initial steps in the Adaptive Management process used to develop this plan, or historical details of the restoration planning process are invited to read the Restoration Plan (Ward and Kier 1999a), MOU, and several other restoration plans that include Battle Creek (CALFED 1999; Ward and Kier 1999b; USFWS 1997; Bernard et al. 1996; CDFG 1996, 1993, 1990; USRFRHAC 1989; CACSST 1988; Hallock 1987). Users of this document who are interested in learning more about the current and proposed activities at the CNFH are encouraged to peruse the Biological Assessment – the document that describes and assesses effects of current or proposed operations of the CNFH and Livingston Stone National Fish Hatchery on ESA-listed populations of anadromous salmonids in the Central Valley (USFWS 2001a).

Table 4. Supporting documents important for understanding the full context of Adaptive Management in Battle Creek.

Cross-Walk to Supporting Documents	
• Battle Creek Salmon and Steelhead Restoration Plan • Memorandum of Understanding for the Battle Creek Salmon and Steelhead Restoration Project • CALFED Ecosystem Restoration Plan • Facility Monitoring Plan • CNFH Biological Assessment • Proposed CNFH Adaptive Management Plan	• Action Specific Implementation Plan for the Battle Creek Salmon and Steelhead Restoration Project • Greater Battle Creek Watershed Strategy (including Fisheries Management Strategy) • Environmental Impact Statement/Environmental Impact Report for the Battle Creek Salmon and Steelhead Restoration Project • Battle Creek Watershed Assessment

This AMP is divided into thirteen major sections, the first three of which constitute the main body of the document and with the remaining sections serving as appendices. The first section, "Battle Creek Restoration Project Description," describes the Battle Creek setting, Restoration Project components, conceptual models used for Restoration Project design and Adaptive Management planning, Adaptive Management uncertainties, Restoration Project goals and objectives, document history, and document organization.

The second section, "Adaptive Management: Development of this tool to address uncertainty in Battle Creek," describes the theoretical components of adaptive management and how the theoretical aspects of Adaptive Management were undertaken within the Restoration Project context.

The third section, "Adaptive Management of the Battle Creek Restoration Project" describes the practical components of adaptive management and how the practice of Adaptive Management will be undertaken upon implementation of the Restoration Project. Included within this section are the Adaptive Management Objectives which constitute the primary enforceable policy direction within this document pertaining to the actual scientific testing of specific hypotheses through studies and monitoring and to the implementation of adaptive responses.

Ten additional sections act as appendices and include components of the plan such as literature citations, FERC license amendment articles, a series of Focused Study plans, and a summation of CALFED Ecosystem Restoration Program Plan Volumes I and II visions and actions related to the Battle Creek watershed and the CNFH.

The AMP provides guidance on implementing the Adaptive Management provisions of the MOU, and is intended to be consistent with the terms of the MOU. Any case where the language in the AMP may conflict with the language in the MOU represents an oversight in the AMP. Therefore, the MOU prevails in any discrepancy that may be discovered between the AMP and the MOU.

II. ADAPTIVE MANAGEMENT: DEVELOPMENT OF THIS TOOL TO ADDRESS UNCERTAINTY IN BATTLE CREEK

The adaptive management process envisioned for Battle Creek is as endorsed in the CALFED Strategic Plan, Healey (2001), and Castleberry et al. (1996) regarding instream flow prescriptions. Adaptive Management used in this plan includes elements of experimentation (see the detailed discussion of experimentation in Section II.C) and, therefore, is a form of "active" adaptive management. However, because specific experimentation of instream flows and facilities modifications were not initially designed into the implementation of the AMP, the AMPT characterizes the restoration of Battle Creek as Passive Adaptive Management where changes in management are made in response to monitoring results.

II.A. Description of Adaptive Management

Adaptive management is an action-oriented approach to restoring or managing natural systems in a manner that improves the health and function of the ecosystem while simultaneously improving our understanding of system dynamics. Although adaptive management may lead to full-scale restoration of a particular ecosystem, the Restoration Project does not address every activity in the entire watershed that affects the ecosystem. Other major activities in the watershed are addressed in the linkages section of the AMP, including watershed-wide development activities and Coleman National Fish Hatchery Adaptive Management Plan (CNFH-AMP) and annual operation plans for the hatchery. To the extent feasible, Restoration Project actions are designed to maximize the opportunity for learning in coordination with other adaptive management efforts in the watershed and the CNFH. Thorough monitoring and evaluation of adaptive management actions is critical to successful learning and resolving scientific uncertainties. Results of monitoring and evaluation will be used to redefine the problem, reexamine goals and objectives, or refine conceptual models to ensure efficient learning and adaptation of management techniques and understanding. Using this process, the AMP is intended to respond to increased knowledge and understanding on an annual basis.

Adaptive management acknowledges uncertainty in the outcome of any management intervention in a system as complex as an ecosystem. The Battle Creek Salmon and Steelhead Restoration Project is especially complex because the water is being allocated for both hydroelectric development and ecosystem services. The primary action in the Restoration Project is increasing the flow of surface water and cold spring water in the stream channel. The Instream Flow Council (2002) recommends that adaptive management be used to answer critical uncertainties for the instream flow-setting process as described in Castleberry et al. (1996). This recommended adaptive management approach for addressing uncertainty associated with instream flow prescriptions suggested that the following steps:

- Set conservative, resource-protective interim flow standards based on available information; and
- Establish a credible monitoring program that allows the interim standards to serve as experiments; and

- Establish an effective procedure that allows revision of the interim standards based on the new information.

The flow setting process used by the Biological Team of the BCWG and the AMP process will be compared to the above procedure.

Because adaptive management requires flexibility and openness, it can become difficult to set up in a regulatory setting such as FERC hydropower licensing process as well as the other federal laws such as the ESA.

In passive adaptive management, the key task is to choose the best management policy (action) given the current understanding of the system and then to monitor implementation to ensure that performance is within expected limits. If possible, implementation should also be used as an opportunity to learn more about the system under management (i.e. address uncertainties in understanding). The following description is from Instream Flow Council 2002 and may be useful in this description of Adaptive Management: "Flow prescriptions are made using predictive models to make statements about flows and what changes can be expected to the hydraulic and water quality measures of habitat. The approach can assume a direct correlation between change in physical habitat and the number of fish or the general status of the ecosystem. Once the habitat objectives and the corresponding flow regime are agreed to, monitoring of the new flow regime can be carried out to verify the predictions. If monitoring does not substantiate the modeled predictions, changes would be made to the models followed by analyses and subsequent alternative recommended flow regimes."

The intent of the adaptive management process is to permit the power of scientific problem solving (experimentation) to be built into management actions in a way that develops better resource management systems (Healey 2001; Walters 1986). The adaptive management process proceeds from definition of a management problem to the modeling of system dynamics and anticipated responses to management options. From evaluation of anticipated system response, adaptive management then proceeds to implementation of specific management option(s) in ways that allow system response to be detected. Finally, monitoring is based on the hypothesized system dynamics and reassessment of the problem, while management actions follow from the results of monitoring (Figure 4; Healey 2001).

The concept of adaptive management is evolving. Presently, there are two overall approaches recognized: active and passive. In general, the active approach applies several proposed management options separated by time or location as a means to discriminate among competing hypothesis of system dynamics. Conversely, the passive approach implements the single most promising management option and monitors its effectiveness versus anticipated results.

In the case of the Restoration Project, a number of actions are being implemented simultaneously as the initial starting point, including instream flow increases, release of cold spring water to streams, passage facility improvements, elimination of potential sources of false attraction to migrating adult fish, and isolation of hydroelectric project water fluctuations from the natural stream reaches. Following application of this initial array of actions, passive adaptive management will be the tool used to monitor effects of the Restoration Project and to apply further modifications where warranted.

II.B. Components of Adaptive Management

The following subsections briefly explain the six steps in passive adaptive management (Table 5), how those steps were carried out in the development of this AMP, and where the reader may find more information about those steps.

Table 5. The six steps of passive adaptive management identified by the CALFED Independent Science Board (Healey 2001).

1. Review the available information so as to define the problem as precisely as possible.
2. Think of plausible solutions to the management problem. Describe these in terms of conceptual models of system behavior and its response to possible management interventions.
3. Subject these solutions to some form of structured analysis (simulation modeling is a useful analytic tool) to determine which offers the greatest promise of success.
4. Specify criteria (indicators, measures) of success or failure of the most promising solution
5. Implement the most promising solution and monitor the system response according to the criteria developed in step 4.
6. Adjust the design of the solution from time to time according to the results of monitoring in an attempt to make it work better.

II.B.1. Step 1: Review of Available information

The first step in formalized passive adaptive management is to review existing information so as to define the management problem as precisely as possible (Table 5; Healey 2001). In the case of Battle Creek, the management problem, at its grossest level, was how to restore currently depressed numbers of anadromous salmonids, in a watershed that historically was one of the most diverse and productive salmon and steelhead streams in the Sacramento River.

The gross-level fishery management problem, low numbers of anadromous salmonids in Battle Creek, was more clearly defined through several restoration planning documents that were based on Contemporary best available science. For example, Hallock (1987) recommended that a salmon restoration plan be developed for Battle Creek upstream of the CNFH. He felt that the major factor suppressing salmon populations was decreased instream flows caused by the PG&E hydroelectric project and that restoration of stream flows could support populations of between 6,000 and 10,000 fall-run Chinook salmon, 2,500 spring-run Chinook salmon, and 1,000 steelhead. The hydroelectric project can divert up to 97 percent of the natural base-flow of the stream and all the major coldwater springs.

The Upper Sacramento Fisheries and Riparian Habitat Advisory Council, established in 1986 by California Senate Bill (SB) 1086, generated a fisheries and riparian habitat management plan which also cited hydroelectric development, and the operation of the CNFH, as the two primary causes for low populations of naturally reproducing salmon and steelhead in Battle Creek. This plan called for:

- increased and stabilized instream flows downstream of hydroelectric project diversions;
- installation of fish screens at project diversions;
- modification of the practice of removing gravel from behind project dams;

- releasing a portion of salmon and steelhead runs, including a continuation of the practice of releasing excess fall Chinook salmon, to Battle Creek upstream from the CNFH;
- completion of habitat studies;
- the development of a specific anadromous fish management plan for Battle Creek and the CNFH

During the late 1980s, a comprehensive fisheries investigation was performed on Battle Creek. Component studies of this investigation provided much of the scientific foundation for subsequent restoration planning. The several components of the fisheries investigation included studies of 1) instream flow (TRPA 1998a), 2) species habitat criteria, 3) fish passage barriers (TRPA 1998b), 4) water temperature (TRPA 1998c, 1998d), 5) fish species abundance (TRPA 1998e), 6) hydrology, 7) sediment and gravel recruitment, and 8) hatchery interactions.

In the early 1990s, another plan was developed to restore and enhance salmon and steelhead in the Central Valley (CDFG 1990). This plan also called for increased instream flows and effective fish screens on Battle Creek. The final recommendations of the California Advisory Committee on Salmon and Steelhead Trout were adopted in SB 2261, passed in 1988, which in turn led to the development of "A Plan for Action" (CDFG 1993) which called for increased stream flows, improving fish passage at Eagle Canyon Dam, installation of fish screens at agricultural and hydroelectric project diversions, passage of fall Chinook salmon above the CNFH to spawn naturally in Battle Creek, and preparation and implementation of a comprehensive plan to restore winter and spring Chinook salmon and steelhead to Battle Creek. One offshoot of the "Plan for Action" was the development of the Steelhead Restoration and Management Plan for California, including Battle Creek (CDFG 1996).

The most definitive attempt to define management problems in Battle Creek began in 1997 with a CALFED Category III contract for development of a comprehensive technical plan to guide implementation of restoration planning efforts and receive advise from interested and affected parties. This effort was completed under the supervision of the BCWG[14] and culminated in the Battle Creek Salmon and Steelhead Restoration Plan and an addendum (Ward and Kier 1999a, 1999b). These two documents summarized instream habitat studies that used best available science in the 1980s (TRPA 1998a, 1998b, 1998c, 1998d, 1998e), and the existing conditions in Battle Creek in the late 1990s including discussions of geology and hydrology, fish populations, selected stream-dependent plants and animals, the history of Battle Creek watershed including hydroelectric project and hatchery operations that contributed to the decline of Battle Creek's anadromous salmonids, Sacramento River fisheries management and environmental factors, and summaries of past and contemporary restoration efforts. The "Technical Plan" section of the Restoration Plan described goals, objectives, and models for the restoration of ecosystem processes in Battle Creek, and documented an analysis of anadromous fish habitat in Battle Creek including, among many others, perceived limiting factors such as instream flow, water temperature, removal of coldwater spring flow, fish passage problems at dams and natural features, and false attraction due to hydroelectric project operations. These two documents also examined perceived limiting factors associated with the operations of the CNFH. All limiting

[14] The BCWG was established by interested and affected parties associated with implementation of the Central Valley Improvement Act to develop an implementation plan for Battle Creek that is effective and has community acceptance, and included representatives of at least 18 agencies and stakeholders. All of the Adaptive Management Parties, including PG&E, USFWS, CDFG, NOAA Fisheries, and USBR, were represented in the BCWG.

factors analyses within these two reports were based on explicit and implicit conceptual models consistent with the formal adaptive management process.

The limiting factors identified by the BCWG are illustrated in Conceptual Model 1. These component conceptual models used in limiting factor analysis, and the process by which the BCWG considered them in the development of their final recommendations, is illustrated in Conceptual Model 2. Nodes A through E of Conceptual Model 2 illustrate the components of the "review of available information."

The Restoration Plan (Ward and Kier 1999a) provided detailed recommendations regarding Battle Creek's hydroelectric-related management problems and, to a lesser extent, watershed activities and the CNFH management options. Potential solutions for Battle Creek's fishery management problems included: actions supporting salmonid restoration in the Battle Creek uplands, in Battle Creek upstream of anadromous fish habitat, and within anadromous fish habitat of Battle Creek; a list of evaluations and studies necessary for salmonid restoration to decrease uncertainty involved in solution identification; and monitoring that would be necessary to ensure that any restoration projects were successful.

The conclusion of the initial "problem definition" step of adaptive management, reached during a long period of restoration planning, resulted in rather precise definitions of the management problem. The gross-level problem of "how to restore anadromous fish" was refined to a list of problem areas that needed to be improved for fish restoration (Ward and Kier 1999a), including:

- insufficient instream flows below PG&E diversion dams limits fish production;
- removal of inflow from major coldwater springs to stream reaches reduces the amount of cold-water habitat at low elevations;
- water allocated to fish restoration is at risk of future reallocation to off-stream uses;
- ramping procedures below diversion dams did not meet the intent of state and federal endangered species laws;
- false attraction of anadromous salmonids from the North Fork to the South Fork leads to unstable population structure and loss of production in the more drought tolerant North Fork, and potentially leads to fish mortality;
- fish passage facilities at dams did not provide safe passage of adult and juvenile salmonids;
- false attraction of anadromous salmonids to the Coleman Powerhouse tailrace potentially causes fish mortality or loss of production;
- natural barriers at Panther Creek on the South Fork limit the habitat available to anadromous salmonids, according to a 1983 assessment of fish passage barriers, but not according to recent observations (CDFG 2001a, 2001b) which indicate the feature is not a barrier at high flow;
- fish passage barriers and low amounts of spawning gravels in a one-half mile reach of Baldwin Creek limit steelhead production;
- fish pathogens flow from salmon habitat to the CNFH's primary water supply on Coleman canal via hydroelectric project diversions and water conveyance systems and might affect the CNFH during times when its ozonation system is inoperative (the ozonation system became operational in 2000; USFWS 1998);

- there is a lack of institutional controls and automated mechanisms which prevent fish entrainment and fluctuating instream flows.

Many other things were excluded from the list because they weren't seen as limiting factors or key components of the management problem including:

- gravel recruitment processes are not disturbed,
- no gravel mining exists in the watershed,
- gravel routing at diversion dams has been addressed by operational procedures,
- riparian community structure is healthy,
- upland land use is isolated from stream channels,
- channel geomorphology is not impaired because diversions do not significantly affect channel maintenance flows,
- exotic fish species would be restricted in range, abundance and effect under restored flow conditions,

Also excluded from the problem definition, because they were addressed by other ongoing management efforts, were such factors outside of the Battle Creek watershed such as:

- water diversions effects in the Sacramento River,
- Sacramento-San Joaquin Delta conditions,
- commercial and sport fishing,
- oceanographic conditions.

Finally, the Restoration Plan, and its addendum entitled "Maximizing Compatibility between Coleman National Fish Hatchery Operations, Management of Lower Battle Creek, and Salmon and Steelhead Restoration (Ward and Kier 1999b), indicated that there was a great deal of uncertainty that Contemporary operations at the CNFH would be fully compatible (as characterized by USFWS 1994) with timely recovery of salmon and steelhead in the restored habitat. The USFWS is currently engaged in an on-going re-evaluation process at the CNFH aimed at identifying potential conflicts between existing hatchery operations and the restoration program, and evaluating potential alternative operational strategies to ensure that the CNFH does not impede the restoration of natural salmon and steelhead populations in Battle Creek. Problem definition and solution identification at the CNFH adequate for formal adaptive management was not completed in these reports.

Following completion of these restoration planning documents, PG&E, NOAA Fisheries, CDFG, USFWS, and USBR undertook a series of negotiations consistent with the formal adaptive management process to further identify solutions to Battle Creek's management problems. The MOU was adopted in June 1999 stating the intent of these MOU Parties to engage in a restoration effort that would modify the facilities and operations of FERC Project No. 1121. The objectives of the Restoration Project are (1) the restoration of self-sustaining populations of Chinook salmon and steelhead and their habitat in the Battle Creek watershed, (2) up-front certainty regarding specific restoration components, (3) timely implementation and completion of restoration activities, and (4) joint development and implementation of a long-term AMP with dedicated funding sources to ensure the continued success of restoration efforts under this partnership.

Restoration and monitoring activities currently underway or planned for Battle Creek are guided by the goals, objectives, and strategies developed in the AFRP (USFWS 2001b). To facilitate restoration of natural salmonid populations in Battle Creek, the CNFH's operations need to be made compatible with the AFRP guided recovery process (USFWS 1994, 1998). Major changes underway at the CNFH include modifications to the hatchery's barrier weir and upstream ladder, improvements/screening of the water intakes, and construction of an ozone water treatment plant (USFWS 2000).

II.B.2. Step 2: Solution Identification and Development of Conceptual Models

The second step in formalized passive adaptive management is to think of plausible solutions to the management problem and describe these in terms of conceptual models of system behavior and likely responses to possible management interventions (Conceptual Model 2; Table 5; Healey 2001). In the case of Battle Creek, the initial, grossest-level solution identification was conducted by a subgroup of the BCWG that did not include PG&E. This subgroup released a working paper in January 1998 entitled "A Time For Action," that was intended to catalyze the planning process by suggesting a list of possible restoration actions (BCWG 1998). Biological, socio-economical, and political analyses were then conducted in response to this working paper, including the description of alternative solutions in terms of conceptual models of system behavior.

The overarching conceptual model (node G in Conceptual Model 2) employed in Battle Creek was the development of a classification system that anticipated the maximum potential restored fish habitat by stream reach and species. Each stream reach within the project-affected portion of the Battle Creek watershed was categorized by professional judgment using a system of five grades depending on a suite of attributes including potentially restorable temperature regime, cold-water accretions from springs, physical habitat characteristics, species life history, length of stream reach, stream gradient, reach elevation, and past observations in similar watersheds[15]. This overarching conceptual model was supported by the use of Reference Watersheds (e.g., Mill and Deer Creeks, Little Sacramento and McCloud Rivers; node E in Conceptual Model 2) and the importance of abundant coldwater spring resources.

This overarching conceptual model was then strengthened by the use of more specific, biological models of key stream reach attributes such as instream flow and potentially usable fish habitat, spawning gravel surveys, water temperature, natural fish passage barriers, and fish passage at diversion dams. Instream flow and available fish habitat was modeled using the instream flow incremental methodology (IFIM), performed by TRPA (1998a),which described the relationship between instream flow and the quantity of fish habitat in each reach of the project-affected area for several fish species and life stages. This instream flow model was interpreted using a limiting life stage model that assessed the relative importance of habitat for three life stages of Chinook salmon, including fry, juvenile, and spawning, through the use of a mathematical model that determined, for each reach, which type of habitat limited production under varying flow regimes. Water temperatures, under possible alternative solutions to the

[15] The concept of Reference Watersheds was developed to "ground-truth" the stream classification system and is used frequently throughout the Adaptive Management process to assess conceptual models, in solution screening exercises, and in developing criteria for measuring the success of the identified solution.

management problem, were modeled using the Stream Network Temperature Model (SNTEMP) (Tu 2001; TRPA 1998c, 1998d) to insure that thermal regimes would approximate those found in other streams supporting spring-run Chinook. Natural fish passage barriers were analyzed by field measurements and the use of a model which helped determine at which flow a potential barrier would become impassable to migrating Chinook and steelhead. Fish passage at diversion dams was considered in light of state and federal standards for fish ladders and criteria for fish screens which have been established to maximize the effectiveness of fish ladders and screens to salmon and steelhead. Furthermore, the cost of fish passage facility modification was compared with diversion dam decommissioning. Finally, economic models of power production were used to estimate economic impacts of various restoration efforts.

II.B.3. Step 3: Solution Screening

The third step in formalized passive adaptive management is to subject alternative solutions to some form of structured analysis (e.g. simulation modeling) to determine which offers the greatest promise of success. (Table 5; Healey 2001). In the Battle Creek case, the BCWG employed a series of four formal policy-level screening mechanism, as well as the use of the various technical models.

The overarching screening mechanism employed in Battle Creek was the concept of ecosystem function (node M of Conceptual Model 2). Mandated by CVPIA and CALFED legislation, all possible solutions were screened to assure that measures undertaken for the benefit of salmon and steelhead would address ecosystem functions or processes (Ward and Kier 1999a).

Alternative solutions were also screened by the policy concept of “stream-dependent economic values” such that possible solutions would: minimize the economic impact of fish restoration on the Battle Creek Hydroelectric Project and to insure the project’s viability; not change any consumptive water rights within the Battle Creek watershed and not affect existing agriculture; and, provide benefits to recreational industries including fishing clubs and guide services, as well as commercial fisheries, by providing more fish to catch (node M of Conceptual Model 2).

Another policy concept of “Maximum Potential Restoration” was used to screen solutions (node M of Conceptual Model 2). Technical models used in identifying solutions considered ecological characteristics (e.g. habitat descriptions, species prioritization, and temperature regimes) that would be achieved under "maximum potential restoration" or similar terms like “reliable,” "complete," or "full" restoration. In general, these tools are used to set targets for what could be achieved if every identified problem affecting anadromous salmonids could be eliminated. Due to the reality of limited restoration funds, the stated goal of balancing restoration with stream-dependent economic values, and other socio-political realities, the BCWG acknowledged that not all possible restoration actions would be implemented as a result of the Restoration Plan. However, they felt these compromises would be best addressed in the recommendations and subsequent restoration actions, rather than to bias the tools used to evaluate the potential for restoration. Therefore, tools used in solution identification generally considered the maximum potential for restoration. An ancillary policy concept was that significant amounts of public monies were identified for the Restoration Project creating an expectation that the actions would be highly certain and reliable compared to normal regulatory processes.

Finally, three policy-level "Biological Principles" were used by the USFWS, NOAA Fisheries, CDFG, and USBR to screen solutions, including: biological effectiveness, restoring natural processes, and biological certainty (node M of Conceptual Model 2). Solutions were required to incorporate the most biologically effective remedies that provide the highest certainty to successfully restore ecosystem functions and self-sustaining populations of native fish in a timely manner. However, hatchery programs to supplement fish populations were not considered because such programs are only one possible element of a recovery planning process led by NOAA Fisheries that is still underway. Solutions were required to incorporate measures that mimic the hydrologic conditions under which Battle Creek anadromous fish resources evolved by increasing baseflows and eliminating mixing of North Fork and South Fork waters. These solutions were to include the removal of diversions at major springs (e.g., in Eagle Canyon and Soap Creek) and the removal of low-elevation dams that fish must pass to reach cold water (e.g., Wildcat and Coleman diversion dams). Solutions were required to provide maximum long-term effectiveness by minimizing long-term dependence on the integrity of man-made restoration actions and the cooperation of future project owners and operators.

Technical-level models were used for screening purposes in many applications (see Ward and Kier 1999a for a complete discussion of all technical analyses used by BCWG). For example, the IFIM instream model and the limiting life stage model were used to screen alternatives (node H of Conceptual Model 2). In particular, the Biological Team of the BCWG, spent nearly a year screening countless alternative instream flow regimes to arrive at a flow regime (named "biologically optimum flows" [16]) which they forecast would typically provide at least 95 percent of the maximum weighted usable area (WUA)[17] for the priority species and limiting life-history stage present at that time. In some cases other considerations took precedence over adherence to the 95 percent of maximum WUA. These considerations included insuring adequate flows for adult salmon migration at natural barriers, balancing overlapping life stages and species, preventing redd dewatering, considering the amount of inflow available at the upstream end of each reach, providing water to preserve the structural integrity of the South Canal[18], and assuming that accretions within the Keswick Reach upstream of the anadromous salmonid habitat would provide the necessary flows in the lower portion of this reach.

Another example of the use of conceptual model to screen solutions was the release of major coldwater springs to the stream and the application of the SNTEMP water temperature

[16] The BCWG prefaced the use of the term "biologically optimum." That name was not intended to imply that these flows are "perfect" or that they provide the maximum potential amount of habitat. Rather, the term identified restored flows that were derived from the best Contemporary methods for determining instream flows, would minimize the take of habitat for listed species pursuant to Section 2081.0 of the California Fish and Game Code, and would carefully balance overlapping ecological needs while recognizing the stated goal of maintaining stream-dependent economic values.

[17] Pursuant to Section 2081.0 of the California Fish and Game Code, the taking of species, listed under the California Endangered Species Act, or their habitat, should be "minimized or fully mitigated." In this case, releasing flows which provided 95 percent of maximum WUA was considered to "minimize" the take of habitat for listed species.

[18] The MOU, written after these analyses, called for decommissioning of this canal.

model to insure that summer water temperatures were suitable for winter-and spring-run Chinook salmon under the “biologically optimum” flow regime (node J of Conceptual Model 2).

The result of the solution identification process was a suite of proposed changes to the facilities and operations of the Battle Creek Hydroelectric Project (Table 2; node N of Conceptual Model 2). This project solution is referred to in this document as the “Restoration Project” and is supported by, and described in detail in, the June 1999 MOU signed by the NOAA Fisheries, USBR, USFWS, CDFG, and PG&E.

Finally, many of the goals and objectives of both the CALFED Ecosystem Restoration Program (ERP) and the CVPIA AFRP were included within the MOU. The CVPIA is a federal statute jointly implemented by the USBR and USFWS. Its goals are consistent with CALFED’s ERP. The CVPIA authorizes a number of projects and programs that contribute to the purposes of the Act and that are consistent with the restoration approach identified in the record of decision for CALFED. In Battle Creek, both CVPIA and CALFED plans, goals, funds, and projects have been utilized to benefit the ecosystem (CALFED 2001).

II.B.4. Step 4: Specification of Criteria of Success

The fourth step in formalized passive adaptive management is to specify criteria of success or failure of the most promising management solution (Table 5; Healey 2001). To make Adaptive Management scientifically feasible in the restoration of Battle Creek, consideration of the “success or failure of the Restoration Project” was divided among a series of individual objectives that closely correspond to the detailed description of the management problem as discussed above. Therefore, the success or failure of the Restoration Project will be measured against many indicators and criteria as described in detail within the eleven Adaptive Management objectives (SectionIII.A).

Conceptual Model 3 (nodes A through F) illustrates the components of the Restoration Project and the ecological processes (Nodes G through T) upon which these components will act. The identification of individual Adaptive Management objectives was based on organizing these processes into discrete objectives with definable, measurable, outcomes that supported the Restoration Project goals of restoring populations of anadromous salmonids in Battle Creek (Nodes U and V).

Criteria vary among the different Adaptive Management objectives and are quite diverse. For example, Population Objective 1 (Spawning and Juvenile Production; **Table 13**) uses the following metrics and criteria to gage the success or failure of obtaining this objective:

<u>Fish Population Objective 1 Metrics</u>:

- estimates of juvenile outmigrant production upstream of the CNFH and at the terminus of each fork of the creek;
- estimates of adult and jack population sizes and distribution;
- evaluations of physical and biological conditions within habitats by reach;

Fish Population Objective 1 Criteria:

- estimates of juvenile outmigrant production will be compared to 1) expected production levels based on adult spawning populations, 2) production levels in Reference Watersheds, and 3) relevant ecological factors.

On the other hand, Habitat Objective 2 (Water Temperature, **Table 18**) uses the following metrics and criteria to gage the success or failure of obtaining this objective:

Habitat Objective 2 Metrics:

- climatic conditions within the South Fork watershed;
- longitudinal water temperature regime of stream;
- flow at springs to which CDFG has conservation water rights;

Habitat Objective 2 Criteria:

- observed water temperature regimes will be compared to water temperatures predicted by the best available Contemporary water temperature models at target points within the stream.

Please refer to individual population, habitat, and fish passage objectives for a complete understanding of the diverse criteria that will be used to gage the success of the Restoration Project.

II.B.5. Step 5: Solution Implementation

The fifth step in formalized passive adaptive management is to implement the most promising solution and monitor the system response according to the criteria developed in step 4 (Table 5; Healey 2001). The MOU described in detail what was considered to be the most promising solution. The USBR has proposed the suite of actions outlined in the MOU as the "preferred alternative" and may implement this solution pending analysis in a formal National Environmental Policy Act/California Environmental Quality Act (NEPA/CEQA) project selection process, and pending receipt of necessary construction permits. A suite of monitoring studies and reporting protocols will be the basis for implementing this AMP (Table 25).

II.B.6. Step 6: Adaptive Responses

The sixth step in formalized passive adaptive management is to adjust the design of the solution from time to time according to the results of monitoring in an attempt to make it work better (Table 5; Healey 2001). As described in more detail below (Section II.B.6), adaptive responses are an integral feature of this AMP. The solution, as implemented in the form of the Restoration Project and considered under the structure of the eleven Adaptive Management objectives, will be evaluated to determine if each objective is being met and whether current actions should continue or if new actions are needed to meet the objectives. Adaptive Management responses could include any major or minor changes to the hydroelectric facility or the natural features of the Restoration Project. Adaptive Management responses have limits identified by the FERC license amendment. Adaptive Management responses falling outside of those allowed by the FERC license amendment provisions would need to be addressed through established FERC processes

II.C. Experimentation

Adaptive management is strongly rooted in scientific experimentation. By specifically designing experiments into management actions, conclusions can be drawn which help develop better resource management decision making. Experimentation in Battle Creek is embodied in three ways, where experimentation: 1) has been a component of Adaptive Management problem definition and solution development, 2) is embodied in the overall Adaptive Management program as envisioned in this document, and 3) may be conducted as part of individual Adaptive Management objectives considered under this plan within the established protocols.

II.C.1. Experimentation in problem definition and solution development

Some early management actions functioned as experiments that helped to develop better resource management decision making in Battle Creek although they were not specifically designed as adaptive management experiments. For instance, during the period from 1985 to 1989, fall-run Chinook were intentionally allowed passage over the CNFH barrier dam, below which they had historically been restricted, and instream flows were increased in the area accessible to these fish in order to assess their use of the habitat upstream of the CNFH. The major conclusions of this experiment were findings that fall-run Chinook would use habitat as far upstream as the Inskip reach, and that the presence of fall-run Chinook in the water supply upstream of the CNFH contributed to subsequent disease outbreaks at the hatchery. This experimentation contributed to the development of improved disease control systems at the CNFH and contributed to the design of new water conveyance facilities that will partially isolate the CNFH water supply as part of the Restoration Project.

A similar management initiative in the late 1990s has also led to adaptive changes in the management of Battle Creek, specifically the development of new instream flow prescriptions as part of the Restoration Project. In 1995, a partnership between PG&E, state and federal fisheries agencies and restoration funding sources (CVPIA and Category III) initiated increases in instream flows at half of the hydroelectric diversions affecting salmon and steelhead within Battle Creek while maintaining FERC minimum instream flows at the remainder of the diversions. Physical (e.g., water temperature, fish passage at natural barriers) and biological responses (e.g., fish distribution) to these flow changes have been monitored and resulting observations have been incorporated into subsequent restoration planning.

II.C.2. Experimentation in the overall adaptive management effort

This AMP does not specify experimentation of proposed instream flows or experimental changes to hydroelectric project facilities at this time. The intent of the MOU Parties was to spend, if necessary, the limited funds available for Adaptive Management on implementing specific remedies to unforeseen short-comings in the Restoration Project, rather than committing these funds to experimentation for goals other than those specific to the Restoration Project. The Adaptive Management Parties recognize the uncertainty surrounding our understanding of ecological processes, and specifically, about how salmon and steelhead populations will respond to initial Restoration Project actions. The Parties recognize that clear-cut population level responses may take decades to be manifested and further recognize that Restoration Project flows and facilities can be viewed as "experimental" in that they may only be in place between 2006 (the expected completion date of Restoration Project) and 2026 (when the FERC license is renewed and new flow regime may be implemented). If alternative flows regimes or facilities modifications are identified for testing, the relicensing process in 2026 offers an opportunity for the Parties to renegotiate what could be seen as the next step of a long-term experiment. Though no specific changes to instream flows or hydroelectric project facilities have been designed into this plan, the AMP was designed to improve the success of long-term experimentation. Theories of experimental design suggest that maximizing the difference between the treatment and control provides the best opportunity for identifying a response. In Battle Creek, the difference between the experimental control (existing conditions under the current FERC license) and the experimental treatment (Restoration Project actions) are so large that a response to these measures should become evident, provided that freshwater habitat conditions in the hydroelectric project reaches indeed limit fish production. For example, existing conditions under the current FERC license are typified by hydroelectric diversions with inadequate fish passage and instream flows that are very low for the target species' life stage needs, while the Restoration Project provides for removal of diversion dams, installation of fish ladders and screens, protection against false attraction, release of major cold-water springs, and instream flow levels on the order of 10 to 29 times greater than existing conditions. Furthermore, the Restoration Project was specifically designed to minimize the uncertainty that is normally explored through experimentation. For example, installation of tailrace connectors should virtually eliminate the current trans-basin water diversions that could otherwise lead to false attraction and confound the relationships between fish production and the other Restoration Project actions. Dam removals and increasing instream flows to levels approaching natural conditions are other examples of minimizing uncertainty.

Should the population objectives not be realized as a result of the Restoration Project and this AMP, then Adaptive Management suggests that other management actions be considered. Fortunately, the time scales of salmon and steelhead restoration (dictated by ecological processes like the population dynamics of small populations and cycles in oceanographic productivity) match up with the time scales of hydroelectric project relicensing. Another opportunity, outside of this AMP, to implement broad-scale changes to the hydroelectric project will be available in 2026 when the project is up for relicensing and this Plan expires.

II.C.3. Experimentation within component objectives

Smaller scale experiments may be a key tool for eliminating future uncertainty in the case that Adaptive Management responses are triggered by unforeseen future conditions. Several component objectives within this plan specify that Diagnostic or Focused Studies will be performed in the case that planned management actions fail to achieve the intended objectives. These studies may be conducted as experiments, depending on the purpose and need and , provided they are feasible, practical, reasonable, prudent, acceptable to the local community, conform to required protocols, and fall within response limits that are specified in criteria which bound potential Adaptive Management responses.

III. ADAPTIVE MANAGEMENT OF THE BATTLE CREEK RESTORATION PROJECT

Narrative text and conceptual models within Section III summarize, in general terms, the rationale and implementation steps of Adaptive Management actions under the AMP. The detailed Objectives Tables (i.e.Table 13, Table 14, Table 15, Table 16, Table 17, Table 18, Table 19, Table 20, Table 21, Table 22, and Table 23), however, constitute the enforceable policy direction contained in Section III. In cases where the language in the narrative text and conceptual models within Section III conflict with the detailed Objectives Tables, policy regarding these topics will be set by the Objectives Tables (i.e.Table 13, Table 14, Table 15, Table 16, Table 17, Table 18, Table 19, Table 20, Table 21, Table 22, and Table 23).

III.A. ADAPTIVE MANAGEMENT OBJECTIVES

This technical chapter of the AMP describes specific Adaptive Management objectives pertaining to the future Adaptive Management of Restoration Project elements, and the scientific methods associated with Adaptive Management of salmon and steelhead populations, habitat, and passage directly affected by the Restoration Project.

The focus of AMP objectives is on the management of salmon and steelhead habitat, and in particular, on hydroelectric project facilities and natural habitat features affected by hydroelectric project operations within the Restoration Project Area. Although the Restoration Project Area includes the north and south forks of Battle Creek upstream to the natural water falls,[19] no elements of the Restoration Project (i.e., neither facilities or operations of the FERC Project No. 1121 modified as part of the Restoration Project) will exist upstream of Inskip and North Battle Creek Feeder Diversion Dams. Therefore, Adaptive Management actions upstream of Inskip Dam and North Battle Feeder Dam will be limited to modification of any natural barriers that may occur up to, but not including, the absolute barriers to anadromous fish passage at the falls on each fork (river mile 18.85 on the South Fork and river mile 13.48 on the North Fork).[19]

Central to the AMP focus on management of habitat is an implicit expectation that salmon and steelhead populations will respond affirmatively to positive changes in their habitat. During the term of the AMP, Restoration Project elements will change fish habitat with the intention of improving that habitat for Chinook salmon and steelhead. The AMTT expects to be able to measure significant responses to these habitat changes from the larger populations of salmonids like steelhead and fall-run Chinook salmon. However, statistically significant responses to these habitat changes in populations of fish that are currently at extremely low levels, such as winter-run Chinook salmon, may not be measurable at least until the populations of these scarce fish grow. This is due to the small number of these fish, limited natural recovery rates, and the limitations of scientific and statistical tools. The ability to adaptively manage

[19] MOU 2.19. The barriers which determine the upstream distribution of anadromous salmonids in Battle Creek at river mile 13.48 on the North Fork of Battle Creek and at river mile 18.85 on the South Fork will not be modified as part of this AMP.

habitat features of Battle Creek based on measurements of scarce populations of winter-run Chinook, and possibly spring-run Chinook, will be severely constrained until such a time that populations levels of these species increase substantially. Adaptive Management actions will not be triggered by biological measurements of scarce species alone; rather, habitat trigger events will need to support the biological indicators. Currently there is not sufficient predictive capability to determine when full recovery of listed species may occur.

The AMP objectives are sufficiently flexible to respond to implementation of approved programs which may change the time scales that apply to fisheries monitoring. However, the AMP objectives do not include artificial propagation or supplementation and do not incorporate potential future fisheries management plans that could implement various kinds of artificial propagation or supplementation programs, because such programs are outside the scope of the Restoration Project. Likewise, the AMP objectives do not exclude artificial propagation or supplementation, activities that may be specified in future fisheries management plans. The AMP objective also do not address the possibility of future development within Battle Creek.

Eleven objectives were identified pertaining to the Adaptive Management of salmon and steelhead populations, habitat, and passage affected by the Restoration Project (Table 6). These objectives were developed primarily from MOU language and pertain to all reasonable and foreseeable interactions between modifications to FERC Project No. 1121 facilities and operations, and salmon and steelhead populations.

The nature of adaptive management, by definition, is to design studies and management programs that can be adapted to uncertain or unforeseen circumstances. A well designed adaptive management plan anticipates as many circumstances as possible before designing monitoring and data assessment approaches. Within the eleven objectives, circumstances or issues that were anticipated include potential limiting factors such as water temperature, habitat quantity based on instream flow, natural barriers, fish passage at diversion dams, problems with facility design or operation, and many more. However, this AMP recognizes that not all future limiting factors could be anticipated. Therefore, many of the objectives refer to future unanticipated factors which could conceivably include things such as institutional changes (e.g., changes to the ESA or other laws), new natural resource management directives (e.g., artificial propagation or supplementation programs), newly understood ecological phenomena (e.g., global climate change), or land and water use changes (e.g., suburbanification of the uplands). Some unanticipated factors may fall outside of the Restoration Project (e.g., toxic spills) and would be addressed through linkages to other programs or directives, while others might be shown to be related to the hydroelectric project or shortcomings in the Restoration Project that could arguably be included under these Adaptive Management objectives (e.g., possible oligotrophication problems in Battle Creek[20]). While this discussion of possible unanticipated factors may seem speculative or fanciful, past experience with adaptive management has shown that the actual factors that are eventually encountered will likely be even more surprising.

[20] The importance of marine-derived nutrients in salmon ecosystems and the possible ramifications to restoration efforts of cultural oligotrophication in streams like Battle Creek, where large numbers of salmon carcasses have been excluded for decades by the hydroelectric project, have been emerging in the awareness of fisheries researchers and managers in the past decade (e.g., Gresh et al. 2000; Stockner et al. 2000).

Table 6. Adaptive Management objectives
of the Battle Creek Salmon and Steelhead Restoration Project.

Salmon and Steelhead Populations
1. Ensure successful salmon and steelhead spawning and juvenile production. 2. Restore and recover the assemblage of anadromous salmonids (i.e., winter-run Chinook, spring-run Chinook, steelhead) that inhabit the stream's cooler reaches during the dry season 3. Restore and recover the assemblage of anadromous salmonids (i.e., fall-run Chinook, late fall-run Chinook) that enter the stream as adults in the wet season and spawn upon arrival. 4. Ensure salmon and steelhead fully utilize available habitat in a manner that benefits all life stages thereby maximizing natural production and full utilization of ecosystem carrying capacity
Salmon and Steelhead Habitat Objectives
1. Maximize usable habitat quantity – volume. 2. Maximize usable habitat quantity – water temperature. 3. Minimize false attraction and harmful fluctuation in thermal and flow regimes due to planned outages or detectable leaks from the hydroelectric project 4. Minimize stranding or isolation of salmon and steelhead due to variations in flow regimes caused by hydroelectric project operations.
Salmon and Steelhead Passage Objectives
1. Provide reliable upstream passage of salmon and steelhead adults at North Battle Creek Feeder, Eagle Canyon, and Inskip Diversion Dams per Contemporary engineering criteria or standards/guidelines. 2. Provide reliable downstream passage of juveniles at North Battle Creek Feeder, Eagle Canyon, and Inskip Diversion Dams per Contemporary criteria after the transfer of facilities to Licensee. 3. Provide reliable upstream passage of adult salmon and steelhead to their appropriate habitat over natural obstacles within the Restoration Project Area while maintaining an appropriate level of spatial separation among the runs.

Adaptive Management used in this plan includes elements of experimentation (see the detailed discussion of experimentation in Section II.C) and, therefore, is a form of "active" adaptive management. However, because specific experimentation of instream flows and facilities modifications were not initially designed into the implementation of the AMP, the AMPT prefers to consider this approach as "passive" adaptive management, where changes in management are made in response to monitoring results.

III.A.1. Objective Table Format

In the following description of objectives and in the accompanying flow chart (Figure 6), the **bold-faced** terms refer to components of the Adaptive Management objective that will be discussed in more detail in the following sections and specifically within the tables detailing each objective.

For each **objective**, the Adaptive Management process will follow a stepwise scientific process beginning with a testable hypothesis which would indicate whether an objective is being met. **Hypotheses** conform to formal adaptive management criteria in that they are statements of cause and effect, are possible answers to a fishery management problem; are a potential description of how the world works; connect the actual management actions with expected outcomes, and are focused and testable (Healey 2001). The scientific methods used to test the hypothesis are identified in this plan as the **monitoring and data assessment approach** and are comprised of established and routine procedures, surveys, analysis, and modeling. These scientific methods will comply with all Contemporary standard methods and reporting practices that are adopted by CALFED and Resource Agencies as they are developed, with provisions for updating methods based on Contemporary scientific norms that are likely to change during the term of the AMP. The AMP will not propose studies that would compromise the recovery of salmon and steelhead. An implementation schedule, or **timeline**, lists the duration and order of monitoring activities for each objective, and includes trigger events and end points. **Trigger events** are circumstances indicating that an adaptive response should be taken and **end points** are a goal or circumstance indicating that an objective has been attained and indicating that monitoring and data assessment is no longer needed under the AMP for that objective. Some objectives may not have end points and will require monitoring and data assessment for entire term of the AMP.

If an objective is not being met and a trigger event occurs, an adaptive **response** would be required, which could involve further Diagnostic studies or modification of the hydroelectric project facilities or operations, or changes to natural features of the Restoration Project Area, designed to bring the system closer to achieving the objective. All responses must be feasible, practical, reasonable, prudent, and acceptable to the local community, though this does not preclude potentially major modifications to project facilities or operations. However, each response has **response limits** which describe the absolute scope of actions that can be taken in response to a trigger event.

Response limits are useful for long-term planning. However, response limits determined by complex processes, like the estimation of the future instream flow needs of salmon and steelhead, are impossible to predict because of unforeseeable changes in the policies or methodologies that will be used to determine them. Also, any changes in minimum flows need to be implemented through Consensus among the Parties and it is impossible to prejudge what that Consensus decision would be. Likewise, response limits may be confounded by conflicts between project goals and unforeseeable trigger events.

In general, response limits under the AMP will be determined by Consensus, guided by principles of feasibility, practicality, reasonability, prudence, local community acceptance, and will conform to limits identified by the FERC license amendment. Possible adaptive responses which fall outside of the FERC license amendment provisions, including major changes in project facilities such as new dams or dam removal, would require further decisions through established FERC processes. In addition, nothing in this AMP is intended to bind or prejudice the Resource Agencies, or otherwise limit their respective authorities, in the performance of their responsibilities under applicable federal and state laws.[21]

[21] MOU 5.7

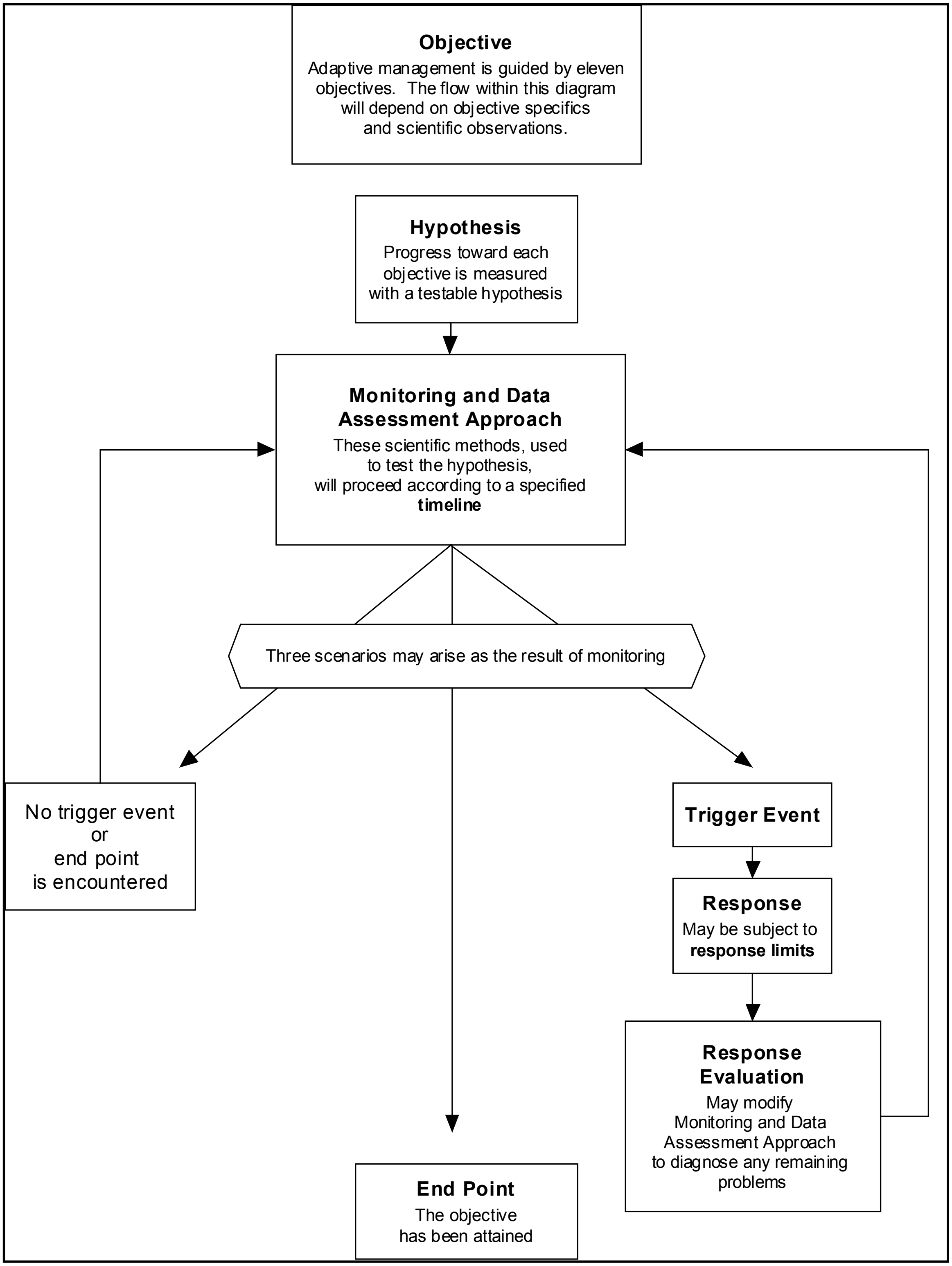


Figure 6. Flow chart depicting components of all Adaptive Management objectives and the general relationships between the various components.

An important component of the Adaptive Management process will be **reporting** which includes emergency reporting procedures, regular periodic reporting, and final long-term reporting as described in subsequent sections. An annual Adaptive Management report will summarize all data collected under these monitoring and data assessment approaches and will present analyses required within each objective. Certified raw data, and reports, generated under these objectives will be updated to appropriate agency and publicly accessible/locally endorsed and maintained information systems using database standards consistent with CMARP, Comprehensive Assessment and Monitoring Program (CAMP), and Environmental Protection Agency (EPA).

Finally, the **responsibility/funding** for each Adaptive Management objective specifies who will fund studies, responses, and reporting.

III.A.2. Population Objectives

The first four Adaptive Management objectives specifically address fish populations in an effort to measure the progress toward the AMP goal of restoring Chinook salmon and steelhead populations to the point they are viable and fully utilizing ecosystem carrying capacity. To do this, accurate assessments of the population size, trends in productivity, population substructure, and population diversity will be critical, though this plan focuses primarily on quantifying population size and trends in productivity. Recovery goals must ensure that natural populations are large enough to avert the risks associated with small population size. Accordingly, both the natural cohort replacement rate (CRR; i.e., trends in productivity) and spawner abundance must be evaluated. This is because a high replacement rate with few parent spawners does not necessarily indicate recovery of the population. Conversely, an abundant spawning population may not indicate a recovered population if the CRR was negative (i.e., a declining population).[22] In order to quantify and gage the progress toward these goals, the AMP has adopted NOAA Fisheries definitions of "viable populations"[23] as the intermediate population target and full utilization of ecosystem carrying capacity as the eventual goal for each species of Chinook salmon and steelhead.

[22] The Cohort Replacement Rate (CRR) is a parameter used to describe the number of future spawners produced by each existing spawner. This spawner-to-spawner ratio is defined as the number of naturally produced and naturally spawning adults in one generation divided by the number of naturally spawning adults (regardless of parentage) in the previous generation. As such, the ratio describes the rate at which each subsequent generation, or cohort, replaces the previous one and can be described as a natural cohort replacement rate (NOAA Fisheries 1997).

[23] As defined in NOAA Fisheries, Draft Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units, January 6, 2000 (NOAA Fisheries 2000), "**Viable salmonid population** is an independent population of any Pacific salmonid (genus *Oncorhynchus*) that has a negligible risk of extinction due to threats from demographic variation (random or directional), local environmental variation, and genetic diversity changes (random or directional) over a 100-year time frame. Other processes contributing to extinction risk (catastrophes and large-scale environmental variation) are also important considerations, but by their nature they need to be assessed at the larger temporal and spatial scales represented by evolutionarily significant units or other entire collections of populations."

III.A.2.a. Population Size

Small populations face a host of risks intrinsic to their low abundance; conversely, large populations exhibit a greater degree of resilience. A large part of the science of conservation biology involves understanding and predicting the effects of population size.[23] NOAA Fisheries has published guidelines for viable population size (Table 7). A population must meet all of the viable population guidelines to be considered viable.[23]

Table 7. NOAA Fisheries viable population size guidelines.[23]

1. A population should be large enough to survive environmental variation of magnitudes observed in the past.
2. A population must have sufficient abundance for any compensatory density dependent processes that affect the population to provide resilience to environmental and anthropogenic perturbation.
3. A population should be sufficiently large to maintain its genetic diversity over the long term.
4. A population should be sufficiently abundant to provide important ecological functions in all the environments it occupies.
5. Population status evaluations should take uncertainty about abundance into account.

The ability to accurately estimate adult and juvenile population sizes, and the validity of inferences drawn from those estimates, may be confounded by small population sizes or large variation in population size and distribution. Conclusions drawn from population estimations will take into account all statistical assumptions and limitations.

These NOAA Fisheries guidelines for viable population size were considered when designing all four Adaptive Management population objectives and should be met through the implementation of these objectives.

III.A.2.b. Trends in Productivity

Trends in abundance reflect changes in factors that drive a population's dynamics and thus determine its abundance. Changes in environmental conditions, including ecological interactions, can influence a population's intrinsic productivity or the environment's ability to support a population (or both), and thus alter the underlying population dynamic over time. Such changes may result from random environmental variation over a wide range of temporal scales (environmental stochasticity). In this section, however, we are most concerned with trends in abundance that reflect systematic changes in a population's dynamics. Therefore changes in abundance caused by environmental stochasticity are treated as "noise" that, although important for estimating the population's extinction risk, acts to obscure persistent trends.[23] Again, NOAA Fisheries has published trends and productivity guidelines (Table 8).

Table 8. NOAA Fisheries trends and productivity guidelines. [23]

1. A population's natural productivity should be sufficient to maintain its abundance above the viable level.
2. A Viable Salmonid Population that includes naturally spawning hatchery fish should exhibit sufficient productivity from naturally produced spawners to maintain population abundance at or above viability thresholds in the absence of hatchery subsidy.
3. A Viable Salmonid Population should exhibit sufficient productivity during freshwater life-history stages to maintain its abundance at or above viable thresholds—even during poor ocean conditions.
4. A Viable Salmonid Population should not exhibit sustained declines in abundance that span multiple generations and affect multiple broodyear-cycles.
5. A Viable Salmonid Population should not exhibit trends in traits that portend productivity declines.
6. Population status evaluations should take into account uncertainty about trends and productivity.

Trends in productivity will be monitored to assess the achievement of the AMP population objectives. To accomplish this, specific actions will be undertaken to monitor CRR. The CRR is a parameter used to describe the number of future spawners produced by each spawner. This spawner-to-spawner ratio is defined as the number of naturally produced and naturally spawning adults in one generation divided by the number of naturally spawning adults (regardless of parentage) in the previous generation. As such, the ratio describes the rate at which each subsequent generation, or cohort, replaces the previous one, and can be described as a natural CRR. When this rate is 1.0, the subsequent cohort exactly replaces the parental cohort and the population is in equilibrium, neither increasing or decreasing. When the rate is less than 1.0, subsequent cohorts fail to fully replace their parents and abundance declines. If the ratio is greater than 1.0, there is a net increase in the number of fish surviving to reproduce naturally in each generation and abundance increases.[24]

For winter-run Chinook, this parameter varies from year to year, but, in the Sacramento River, values of less than 1.0 were observed in the past, as expected in a decreasing population. In Battle Creek, environmental and habitat conditions will have to be improved enough to rebuild the population and to observe CRR values greater than 1.0. CRR must then remain at least near 1.0 for a period of time of high abundance to consider the species viable.[24]

When estimating the value of CRRs, the true value will not be known. Hence, a certain number of samples will be needed to obtain an adequate precision. For example, to adequately estimate CRR for winter-run Chinook in the Sacramento River, NOAA Fisheries determined that the number of samples necessary is 9, which requires 13 years of observation of spawner abundance because the maximum spawning age is 4 years (NOAA Fisheries 1997). In Battle Creek, the sampling period is unknown because the population estimation precision is unknown. However, guidance on this issue will likely be forthcoming upon completion of NOAA Fisheries' Viable Salmonid Population definition process.

[24] NOAA Fisheries Proposed recovery plan for the Sacramento River Winter-run Chinook salmon. p IV-2.

These NOAA Fisheries guidelines for trends and productivity were considered when designing all four Adaptive Management population objectives and should be met through the implementation of these objectives.

III.A.2.c. Population Substructure

When evaluating population viability, it is important to take within-population spatial structure needs into account for two main reasons: (1) because there is a time lag between changes in spatial structure and species-level effects, overall extinction risk at the 100-year time scale may be affected in ways not readily apparent from short-term observations of abundance and productivity; and (2) population structure affects evolutionary processes and may therefore alter a population's ability to respond to environmental change.[24] The first reason applies to the important conservation goal of restoring Battle Creek as a hedge against the extinction of winter-run Chinook, and the second reason is important because many habitats in which Battle Creek fish live will not be specifically managed by AMP objectives (e.g., land use in the upper watershed, Sacramento-San Joaquin Delta). The attention given in the AMP to sub-watershed production estimates (i.e., within the two forks of Battle Creek), as well as the false attraction and reach-by-reach habitat protection measures, were designed to meet the NOAA Fisheries guidelines for spatial structure (Table 9).

Table 9. NOAA Fisheries spatial structure guidelines.[23]

1. Habitat patches should not be destroyed faster than they are naturally created.
2. Natural rates of straying among subpopulations should not be substantially increased or decreased by human actions.
3. Maintain some habitat patches that appear to be suitable or marginally suitable, but currently contain no fish.
4. Source subpopulations should be maintained.
5. Analyses of population spatial processes should take uncertainty into account.

III.A.2.d. Population Diversity

Several salmonid traits exhibit considerable diversity within and among populations, and this variation has important effects on population viability (Appendix A.7). Some of these varying traits are anadromy, morphology, fecundity, run timing, spawn timing, juvenile behavior, age at smolting, age at maturity, egg size, developmental rate, ocean distribution patterns, male and female spawning behavior, physiology and molecular genetic characteristics. Of these traits, some (such as DNA or protein sequence variation) are completely genetically based, whereas others (such as nearly all morphological, behavioral, and life-history traits) usually vary as a result of a combination of genetic and environmental factors.

In a spatially and temporally varying environment, there are three general reasons why diversity is important for species and population viability. First, diversity allows a species to use a wider array of environments than they could without it. For example, varying adult run and spawn timing allows several salmonid species to use a greater variety of spawning habitats than would be possible without this diversity. Second, diversity protects a species against short-term spatial and temporal changes in the environment. Fish with different characteristics have different likelihoods of persisting – depending on local environmental conditions. Therefore, the more diverse a population is, the more likely it is that some individuals would survive and reproduce in the face of environmental variation. Third, genetic diversity provides the raw material for surviving long-term environmental changes. Salmonids regularly face cyclic or directional changes in their freshwater, estuarine, and ocean environments due to natural and human causes, and genetic diversity allows them to adapt to these changes.[25]

The AMP passage objectives take great steps towards restoring the natural process of dispersal throughout the Battle Creek watershed while AMP habitat objectives are intended to aid in the restoration the ecosystem function, essentially those natural processes that cause ecological variation (Table 10). Other human-caused factors have been previously identified in the Battle Creek watershed (e.g., see Ward and Kier 1999b for a summary of concerns) that affect population diversity, including traits such as run timing, age structure, size, fecundity, behavior, and molecular genetic characteristics, include the operation of the CNFH barrier dam, hatchery selection of spawning fish, use of Sacramento River winter-run Chinook in Battle Creek, and superimposition by hatchery fish on wild fish redds. Factors from outside of the Battle Creek watershed also affect these population diversity traits including operations of water diversions (e.g., Red Bluff Diversion Dams, delta pumps), commercial and sport fisheries, and temperature control in the Sacramento River (NOAA 1994; CDFG 1998). These activities which may threaten population diversity will be addressed through the AMP linkages.

Table 10. NOAA Fisheries diversity guidelines. [23]

1. Human-caused factors such as habitat changes, harvest pressures, artificial propagation, and exotic species introduction should not substantially alter traits such as run timing, age structure, size, fecundity, morphology, behavior, and molecular genetic characteristics.
2. Natural processes of dispersal should be maintained. Human-cased factors should not substantially alter the rate of gene flow among populations.
3. Natural processes that cause ecological variation should be maintained.
4. Population status evaluations should take uncertainty about requisite levels of diversity into account.

III.A.2.e. Viable Population Sizes and Interim Quantitative Population Goal

The AMP has adopted NOAA-Fisheries definitions of "viable populations" as the intermediate population goal and identifies the maximization of salmon and steelhead production and full utilization of carrying capacity as the final goal. At this time, numerical targets for Viable Salmonid Population levels of ESA-listed stocks in Battle Creek have not yet been determined by NOAA-Fisheries. However, the adaptive management process requires that quantitative goals be established against which progress in the implementation of adaptive management actions can be measured.

Quantitative estimates of adult salmon spawner abundance necessary to achieve genetically viable population levels (per definition by NOAA-Fisheries; McElhany et al. 2000) is difficult to determine and would best be left to the determination of the NOAA-Fisheries

[25] NOAA Fisheries Proposed recovery plan for the Sacramento River Winter-run Chinook salmon. p IV-20-21.

Technical Review Team who administers salmonid stocks listed under the ESA. However, for the purposes of Adaptive Management, the AMTT has determined that 1,000 adult spawners per year of steelhead and each of four races of Chinook salmon could serve as an interim quantitative goal until such a time that NOAA-Fisheries Technical Review Team establishes quantitative viable population levels.

To determine this interim quantitative goal, the AMTT considered several concepts of population genetic theory. One important concept is that of effective population size (N_e, Wright 1931 and Crow and Kimura 1970 as cited in McElhany et al. 2000). The effective size of a population is defined as the size of an idealized population that would produce the same level of inbreeding or genetic drift seen in an observed population in which one is interested (see Hartl and Clark 1989, Caballero 1994 for reviews as cited in McElhany et al. 2000). McElhany et al. (2000) reviews several estimates of the number of breeders per generation necessary to avoid deleterious genetic effects (Table 11).

Table 11. Recommended effective population sizes.

Recommended Effective Population Size (N_e)	Citation
50 to avoid inbreeding depression	Franklin 1980
500 for long-term population persistence	Franklin 1980, Soulé 1980
5,000 for long-term population persistence	Lande 1995
1,000 for long-term population persistence	Lynch 1990
1,000 for “no danger of serious loss of diversity”	Technical Review Panel 2004
100 per year for short-term genetic maintenance	Waples 1990

Based on genetic evidence, Allendorf et al. (1997) concluded that salmon populations with N_e below 500 (or N below 2,500) per generation would be at high risk and populations with N_e below 50 (or N below 250) per generation would be at very high risk. Wainwright and Waples (1998) noted that if demographic factors were included, thresholds for these categories would be higher, but they did not suggest specific values.

Reiman and Allendorf (2001) summarize effective population size recommendations with the so called “50/500” rule in a review relevant to conservation management. They report that the generally accepted rule is that N_e of less than about 50 is vulnerable to inbreeding depression. Although populations might occasionally decline to numbers on this order without adverse effects, maintenance of adaptive genetic variation over longer periods of time (e.g., centuries) probably will require an N_e averaging more than 500 (Allendorf and Ryman in press, as cited in Reiman and Allendorf 2001).

The most conservative way of gaging the success of the Restoration Project would be to set population goals in terms of effective population size (N_e). However, determining N_e and N can be complicated (e.g. Reiman and Allendorf 2001; Shrimpton and Heath 2003) and requires either detailed information on population demographics and breeding structure (e.g. sex ratio, Nelson and Soulé 1987; variation in age at maturity, and repeat spawning in steelhead, Reiman and Allendorf 2001) or extensive information on genetic population structure (Reiman and

Allendorf 2001). An appropriate estimate of *N* would be the mean number of adults observed across years times generation length.

As a result, in Battle Creek, the AMTT will rely on an estimate of N_e, assumed to be some fraction of number of breeders per generation (*N*), as estimated by monitoring the number of spawners per year (N_b; Reiman and Allendorf 2001), and will specify interim population goals in terms of N_b.

In order to convert the recommendations of effective population size per generation in Table 11 to targets of yearly salmon spawning abundance, it is necessary to know the ratio of the effective number of breeders (N_b) to the observed number of breeders per generation (*N*) and the generation time for the population in question. Several studies suggest that a N_b/N ratio of 0.3 is approximately correct for salmon and steelhead in general (McElhany et al. 2000). With this ratio, the recommended minimum long-term genetically viable population sizes presented in Table 11 range from 1,670/generation (Franklin 1980 and Soulé 1980) to 16,700/generation (Lande 1995). The minimum spawning population size recommended by WDFW (1997) falls in this range (3,000/generation). For populations that spawn at multiple age classes, the spawners-per-generation value must be divided by the generation length (median age of reproduction) to obtain the corresponding numbers of spawners per year. For example, in Battle Creek, steelhead, spring-run Chinook, and winter-run Chinook have an approximate generation time of 3 years. A range of about 557 to 5,567 breeders per year[26], therefore, may be reasonable minimum values for maintaining sufficient genetic diversity to ensure long-term persistence of Chinook salmon populations.

The interim quantitative goal of 1,000 adult spawners per year falls within the range of 557 to 5,567 breeders per year described by McElhany et al. (2000). Reiman and Allendorf's (2001) most realistic estimates of N_e were between about 0.5 and 1.0 times the mean number of adults spawning annually. They concluded that cautious long-term management goals for bull trout populations should include an average of at least 1,000 adults spawning each year. However, in a study of five populations of Chinook, Shrimpton and Heath (2003) found little concordance between census population size and genetic-based population parameters (i.e. genetic diversity, N_e) despite considerable variation in both census population size and genetic parameters. For example, Bowron River Chinook underwent a dramatic increase in population size (from less than 1,000 to about 9,000 adults per year but showed a decline in heterozygosity and allele number over the study period (N_e estimates ranged from 126 to 267.5). Shrimpton and Heath (2003) conclude that management decisions based on interpretations of population health should not rely exclusively on census estimates.

While much of this literature suggests that the interim quantitative goal in Battle Creek of 1,000 spawners per year is a valuable estimate, the findings by Shrimpton and Heath (2003) emphasize the need for a more accurate determination of viable population size by the NOAA-Fisheries Technical Review Team.

Implicit within these interim quantitative goals for the Battle Creek Salmon and Steelhead Restoration Project is an understanding that maintenance of the full expression of life

[26] In fish with a four-year generation time, this range would be about 418 to 4,175 adult spawners per year.

history, dispersal, and the phenotypic diversity that can be distributed among diverse habitats may be as important as maintenance of genetic variation if populations are to remain resilient and productive in the face of natural disturbances (Healey 1994; Healey and Prince 1995; Rieman and Dunham 2000). Maintenance of genetic diversity is essential, but not necessarily sufficient, for effective conservation. Therefore, we refer the reader to the other non-quantitative aspects of viable populations that are managed for within the AMP (see preceding sections III.A.2.c. to III.A.2.d).

III.A.2.f. Carrying Capacity

Carrying capacity represents a population size that the resources of the environment can maintain without large fluctuations. As populations fully utilize their environment, competition between the same species for resources (intraspecific competition) acts to equalize the birth and death rates, thus stabilizing the population. Carrying capacity changes. For instance, the carrying capacity of Battle Creek for anadromous salmonids in the post-restoration state is expected to be much higher than the current depressed carrying capacity.

The natural environment must be able to support large enough populations to reduce radical fluctuations associated with small populations (demographic stochasticity) and environmental variation. Current salmon and steelhead populations, particularly winter- and spring-run Chinook, are small enough to be susceptible to extinction as a result of random events tied to reproduction. Therefore, the objectives of this AMP are to increase habitat volume and quality, and fish access to habitat, so that salmon and steelhead populations increase to a size where risks from random variation associated with demographics and the environment are minimized. With the implementation of the Restoration Project, the CRR average is expected to rise above 1.0 for consecutive generations to rebuild salmon and steelhead populations. As populations begin to reach carrying capacity, the CRR trend will begin to decline and stabilize near 1.0. If the three-year running CRR average falls below 1.0 and the viable populations standard has not been met, the limiting factors will be identified and addressed by the AMP.

Carrying capacity is reached when the CRR has stabilized for several generations at 1.0 after many generations of a CRR greater than 1.0. It is possible that the carrying capacity could be reached but the populations remain below the "viable population" levels or estimated maximum natural production levels, or the viable population standard could be met, but be below the carrying capacity. Thus, in evaluating carrying capacity and viable populations, it is important to consider condition of the habitat, absolute population size, and the CRR. Furthermore, naturally caused fluctuations in populations, and the long period of time that CRR must average 1.0, confound the ability to determine when populations are at carrying capacity.

No formal estimates of carrying capacity have been generated for Battle Creek, either in its pre-restoration or post-restoration states. The Restoration Project is expected to increase the carrying capacity of the watershed, though the methods to precisely determine carrying capacity are limited at this time. The AMTT will work to identify when salmon and steelhead are fully utilizing the restored habitat of Battle Creek. The AMTT may use USFWS (1995; Table 12) as guidance. USFWS (1995) predicted population sizes of Chinook salmon and steelhead in Battle Creek after implementing restoration measures that were less comprehensive than those proposed under the Restoration Project.

Table 12. Predicted population sizes of Chinook salmon and steelhead in Battle Creek after implementing restoration measures outlined in USFWS (1995).

Battle Creek Anadromous Fish Populations	Numbers of Adult Fish
Winter-run Chinook salmon	2,500
Spring-run Chinook salmon	2,500
Fall-run Chinook salmon	4,500
Late fall-run Chinook salmon	4,500
Steelhead	5,700
Total	**19,700**

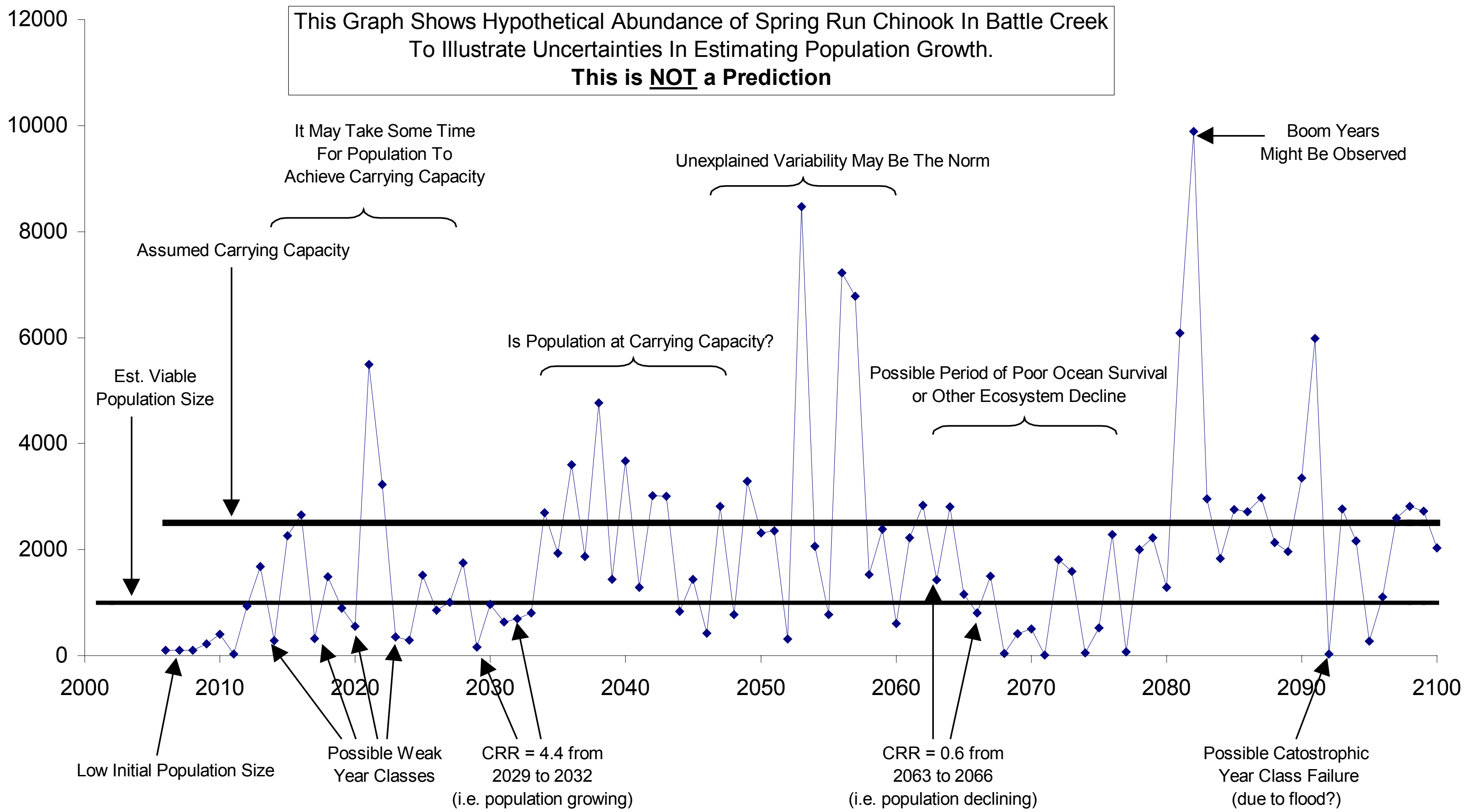


Figure 7. Population growth uncertainties model.

Table 13. Population Objective 1 – Spawning and juvenile production.

POPULATION OBJECTIVE 1

Ensure successful salmon and steelhead spawning and juvenile production.

HYPOTHESIS: Implementation of instream flow levels and facilities modifications specified in the description of the Restoration Project, implementation of the Facilities Monitoring Plan, and implementation of any adaptive responses affecting instream flows or hydroelectric project facilities, will ensure that juvenile salmon and steelhead production is within the expected level given the number of spawning adults and relevant ecological factors..

MONITORING AND DATA ASSESSMENT APPROACH: (1) Establish baseline estimates of juvenile production using outmigrant traps at the terminus of the Restoration Project Area upstream of the CNFH;[27] (2) Estimate adult and jack population sizes and distribution using adult counts at fish ladders, carcass counts, snorkel surveys, or redd surveys; (3) Estimate juvenile production using an outmigrant trap at the terminus of the Restoration Project Area upstream of the CNFH; (4) Estimate juvenile production using outmigrant traps at the terminus of each fork during years and seasons as needed, when adult population levels are sufficient to produce statistically detectable numbers of juvenile outmigrants;[28] (5) Note qualitative changes in physical and biological conditions within habitats by reach during the course of all other studies (e.g. stream surveys, snorkel surveys, radiotelemetry surveys); (6) Compare juvenile production, by fork and mainstem reach, with production expected from previous spawning populations, in those areas, in light of relevant ecological factors; (7) Compare juvenile production, by fork and mainstem reach, with production observed in Reference Watersheds; (8) Conduct a Diagnostic Study in 2008 of the distribution and abundance of spawning gravels to revise 1988 estimates.

TIMELINE: (1) Each monitoring and data assessment approach applies separately for each run of salmon and steelhead to reflect the diversity of life histories;[29] (2) Sample juvenile production when adult population levels are sufficient to produce statistically detectable numbers of juvenile outmigrants; (3) Sample, when feasible, juvenile production during all periods of juvenile movement; (4) Sample juvenile production especially during drought.

TRIGGER EVENT: Juvenile production not within expected range given the number of spawning adult salmon and steelhead and relevant ecological factors. For example, if a year-class failure occurs in Battle Creek but not in Reference Watersheds.

RESPONSE: (1) If the limiting factor is flow-related, the response would be that set forth in Habitat Objective 1; (2) If the limiting factor is water temperature-related, the response would be that set forth in Habitat Objective 2; (3) If the limiting factor is unidentifiable after testing hypotheses from all habitat and passage objectives, identify unanticipated limiting factors and work to eliminate those factors that are controllable and related to the Restoration Project.[30]

RESPONSE LIMITS: (1) If the limiting factor is identified by testing hypotheses from any of the habitat and passage objectives, the response limits would be based on the appropriate objective; (2) If the limiting factor is not associated with any of the objectives, but is controllable and related to the Restoration Project, the response limit will be any action deemed feasible, practical, reasonable, prudent, acceptable to the local community, and consistent with MOU and FERC protocols, provided that Consensus has been reached among the Parties.

RESPONSE EVALUATION: Per standard response evaluation described above.

END POINT: (1) There is no end point for juvenile production monitoring at the terminus of the Restoration Project Area upstream of the CNFH; (2) There is no end point for estimating adult and jack population sizes; (3) Trapping on the forks will continue until the AMTT decides it is no longer necessary (i.e., the hypothesis is met during a reasonable number of years of extreme water conditions); (4) Comparisons of actual versus expected juvenile production, and comparisons with Reference Watersheds are terminated when Population Objective 4 has been reached and juvenile production is within the expected range.

REPORTING: Per standard data management and reporting procedures described in sections III.D.7 and III.D.8.b

RESPONSIBILITY/FUNDING: (1) Licensee will conduct or fund, up to the Licensee's Commitment, adult counts at fish ladders in the initial three-year period of operation. Pursuant to Adaptive Management protocols, if salmon and steelhead populations are insufficient to affirm ladder effectiveness under continuous duty, Licensee will conduct or fund adult counts at fish ladders for a longer period of time to be determined by mutual agreement per protocols. (2) Resource Agencies will, subject to available funds, conduct or fund or seek funding for other monitoring and data assessments.

---

[27] Establishing baseline estimates of production are important to prove the results of the Restoration Project, as a foundation for adaptive management, and to comply with CAMP protocols. Pre-project production estimates under the present interim flow agreement were not part of the MOU charge and are not attainable with screw traps. Baseline estimates will be made in the first brood year of winter run (2007) and the first brood year of spring run (2008). Additional information on juvenile production will be learned through the Juvenile Habitat Use Focused Study.

[28] Monitoring in both forks is important because of different habitats, limiting factors, and management actions/facilities within each fork.

[29] See Ward and Kier (1999a) for life history information.

[30] The response to factors that are controllable but not related to the Restoration Project will depend on the appropriate agency initiatives identified in the "Linkages" section of this report. Identification of uncontrollable factors could lead to a reassessment of "relevant ecological factors."

Table 14. Population Objective 2 – recover winter-run Chinook, spring-run Chinook, and steelhead.

POPULATION OBJECTIVE 2

Restore and recover the assemblage of anadromous salmonids (i.e., winter-run Chinook, spring-run Chinook, steelhead) that inhabit the stream's cooler reaches during the dry season

HYPOTHESIS: Implementation of instream flow levels and facilities modifications specified in the description of the Restoration Project, implementation of the Facilities Monitoring Plan, and implementation of any adaptive responses affecting instream flows or hydroelectric project facilities, will ensure that populations of spring-run Chinook, winter-run Chinook and steelhead are at viable population levels.

MONITORING AND DATA ASSESSMENT APPROACH: (1) Estimate adult and jack population sizes using adult counts at fish ladders, carcass counts, snorkel surveys, or redd surveys; (2) Estimate juvenile production using outmigrant traps within the Restoration Project Area;[27] (3) Calculate, analyze, and monitor CRRs (CRR) according to protocols; (4) After population levels are sufficient to reliably calculate CRR, compare 3-year running average CRR with expected CRR; (5) Compare trends in CRR with limiting factors from outside the Restoration Project Area using the linked monitoring in the Sacramento River system; (6) Compare trends in CRR with Reference Watersheds.

TIMELINE: (1) Each monitoring and data assessment approach applies separately for each run of salmon and steelhead to reflect the diversity of life histories; (2) Estimates of adult population size and juvenile production will be made throughout the term of the AMP or until this Objective is met; (3) CRR protocols suggest that calculation and analysis of CRR will continue for a minimum of 13 years plus 3 years and will likely extend for at least the term of the AMP.

TRIGGER EVENT: The three-year running average CRR falls below 1.0 after CRR can be reliably calculated according to CRR protocols above, and trends in CRR differ from CRR trends in Reference Watersheds.

RESPONSE: (1) If the limiting factor is flow-related, the response would be that set forth in Habitat Objective 1; (2) If the limiting factor is water temperature-related, the response would be that set forth in Habitat Objective 2; (3) If the limiting factor is unidentifiable after testing hypotheses from all habitat and passage objectives, identify unanticipated limiting factors and work to eliminate those factors that are controllable and related to the Restoration Project.[31]

RESPONSE LIMITS: (1) If the limiting factor is identified by testing hypotheses from any of the habitat and passage objectives, the response limits would be based on the appropriate objective; (2) If the limiting factor is not associated with any of the objectives, but is controllable and related to the Restoration Project, the response limit will be any action deemed feasible, practical, reasonable, prudent, acceptable to the local community, and consistent with MOU and FERC protocols, provided that Consensus has been reached among the Parties.

RESPONSE EVALUATION: Per standard response evaluation described above.

END POINT: Continue these monitoring and data assessment approaches, separately for each run of salmon and steelhead, until populations reach viable population levels.

REPORTING: Per standard data management and reporting procedures described in sections III.D.7 and III.D.8.b

RESPONSIBILITY/FUNDING: (1) Licensee will conduct or fund, up to the Licensee's Commitment, adult counts at fish ladders in the initial three-year period of operation. Pursuant to Adaptive Management protocols, if salmon and steelhead populations are insufficient to affirm ladder effectiveness under continuous duty, Licensee will conduct or fund adult counts at fish ladders for a longer period of time to be determined by mutual agreement per protocols. (2) Resource Agencies will, subject to available funds, conduct or fund or seek funding for other monitoring and data assessments. (3) NOAA Fisheries will define recovery goals for anadromous salmonid species in Battle Creek listed under the ESA at any time during the term of the AMP.

[31] The response to factors that are controllable but not related to the Restoration Project will depend on the appropriate agency initiatives identified in the "Linkages" section of this report. Identification of uncontrollable factors could lead to a reassessment of "relevant ecological factors."

Table 15. Population Objective 3 – recover fall-run Chinook and late fall-run Chinook.

POPULATION OBJECTIVE 3

Restore and recover the assemblage of anadromous salmonids (i.e., fall-run Chinook, late fall-run Chinook) that enter the stream as adults in the wet season and spawn upon arrival.

HYPOTHESIS: Implementation of instream flow levels and facilities modifications specified in the description of the Restoration Project, implementation of the Facilities Monitoring Plan, and implementation of any adaptive responses affecting instream flows or hydroelectric project facilities, will ensure that populations of fall-run Chinook and late fall-run Chinook are at viable population levels.

MONITORING AND DATA ASSESSMENT APPROACH: (1) Estimate adult and jack population sizes and distribution using adult counts at fish ladders, carcass counts, snorkel surveys, or redd surveys; (2) Estimate juvenile production using outmigrant traps within the Restoration Project Area;[27] (3) Calculate, analyze, and monitor CRRs according to protocols; (4) After population levels are sufficient to reliably calculate CRR, compare 3-year running average CRR with expected CRR; (5) Compare trends in CRR with limiting factors from outside the Restoration Project Area using the linked monitoring in the Sacramento River system; (6) Compare trends in CRR with Reference Watersheds.

TIMELINE: (1) Each monitoring and data assessment approach applies separately for each run of salmon to reflect the diversity of life histories; (2) Estimation of adult population size and juvenile production will be made throughout the term of the AMP or until this Objective is met; (3) CRR protocols suggest that calculation and analysis of CRR will continue for a minimum of 13 years plus 3 years and will likely extend for at least the term of the AMP.

TRIGGER EVENT: The three-year running average CRR falls below 1.0 after CRR can be reliably calculated according to CRR protocols above and trends in CRR differ from CRR trends in Reference Watersheds.

RESPONSE: (1) If the limiting factor is flow-related, the response would be that set forth in Habitat Objective 1; (2) If the limiting factor is water temperature-related, the response would be that set forth in Habitat Objective 2; (3) If the limiting factor is unidentifiable after testing hypotheses from all habitat and passage objectives, identify unanticipated limiting factors and work to eliminate those factors that are controllable and related to the Restoration Project.[32]

RESPONSE LIMITS: (1) If the limiting factor is identified by testing hypotheses from any of the habitat and passage objectives, the response limits would be based on the appropriate objective; (2) If the limiting factor is not associated with any of the objectives, but is controllable and related to the Restoration Project, the response limit will be any action deemed feasible, practical, reasonable, prudent, acceptable to the local community, and consistent with MOU and FERC protocols, provided that Consensus has been reached among the Parties.

RESPONSE EVALUATION: Per standard response evaluation described above.

END POINT: Continue these monitoring and data assessment approaches, separately for each run of salmon and steelhead, until populations reach viable population levels.

REPORTING: Per standard data management and reporting procedures described in sections III.D.7 and III.D.8.b

RESPONSIBILITY/FUNDING: (1) Licensee will conduct or fund, up to the Licensee's Commitment, adult counts at fish ladders in the initial three-year period of operation. Pursuant to Adaptive Management protocols, if salmon and steelhead populations are insufficient to affirm ladder effectiveness under continuous duty, Licensee will conduct or fund adult counts at fish ladders for a longer period of time to be determined by mutual agreement per protocols. (2) Resource Agencies will, subject to available funds, conduct or fund or seek funding for other monitoring and data assessments. (3) NOAA Fisheries will define recovery goals for anadromous salmonid species in Battle Creek listed under the ESA including species that may not be listed at the time the AMP was originally drafted.

[32] The response to factors that are controllable but not related to the Restoration Project will depend on the appropriate agency initiatives identified in the "Linkages" section of this report. Identification of uncontrollable factors could lead to a reassessment of "relevant ecological factors."

Table 16. Population Objective 4 – carrying capacity.

POPULATION OBJECTIVE 4

Ensure salmon and steelhead fully utilize available habitat in a manner that benefits all life stages, thereby maximizing natural production and full utilization of ecosystem carrying capacity.

HYPOTHESIS: Implementation of instream flow levels and facilities modifications specified in the description of the Restoration Project, implementation of the Facilities Monitoring Plan, and implementation of any adaptive responses affecting instream flows or hydroelectric project facilities, will ensure that, once populations of anadromous salmonids are at viable population levels, the natural production of populations of anadromous salmonids within the Restoration Project Area is maximized based on full utilization of habitat and ecosystem carrying capacity.

MONITORING AND DATA ASSESSMENT APPROACH: (1) Continue monitoring specified in Population Objective 3 for this objective after each population of anadromous salmonid reaches viable population levels; (2) Estimate adult and jack population sizes using adult counts at fish ladders, carcass counts, snorkel surveys, or redd surveys; (3) Estimate juvenile production using outmigrant traps and other Contemporary sampling techniques within the Restoration Project Area;[27] (4) Define the carrying capacity of each species and life stage of salmon and steelhead and compare populations with expectations of carrying capacity; (5) Determine if natural production in the Restoration Project Area is maximized; (6) Calculate, analyze, and monitor CRR according to protocols; (7) Compare 3-year running average CRR with expected CRR; (8) Compare long-term CRR trend for a decade and compare with a consistent value of 1.0.

TIMELINE: (1) Each monitoring and data assessment approach applies separately for each species of salmon or steelhead to reflect the diversity of life histories; (2) Estimation of adult population size and juvenile production will be made throughout the term of the AMP or until this Objective is met; (3) CRR protocols suggest that calculation and analysis of CRR will continue for a minimum of 13 years plus 3 years and will likely extend for at least the term of the AMP.

TRIGGER EVENT: (1) The three-year running average CRR falls below 1.0 after Viable Populations Levels have been reached, and long-term trends in CRR differ from CRR trends in Reference Watersheds; (2) CRR reach a consistent value of 1.0 for several generations but the populations size(s) are less than the expected carrying capacity; (3) Natural production of any species or life history stage in the Restoration Project Area is less than expected levels of production.

RESPONSE: If CRR falls below 1.0 and long-term trends differ from Reference Watersheds, or if CRR stabilizes at 1.0 but the populations sizes are lower than expected, or if natural production of any species or life history stage is less than expected, identify unanticipated limiting factors, and either work to eliminate those factors that are controllable, related to the Restoration Project, and within response limits, or refine estimates of expected carrying capacity.

RESPONSE LIMITS: (1) If the limiting factor is identified by testing hypotheses from any of the habitat and passage objectives, the response limits would be based on the appropriate objective; (2) If the limiting factor is not associated with any of the objectives, but is controllable and related to the Restoration Project, the response limit will be any action deemed feasible, practical, reasonable, prudent, acceptable to the local community, and consistent with MOU and FERC protocols, provided that Consensus has been reached among the Parties.

RESPONSE EVALUATION: Per standard response evaluation described above.

END POINT: Continue these monitoring and data assessment approaches, separately for each run of salmon and steelhead, until natural production within the Restoration Project Area is maximized and ecosystem carrying capacity is fully utilized.

REPORTING: Per standard data management and reporting procedures described in steins III.D.7 and III.D.8.b

RESPONSIBILITY/FUNDING: (1) Licensee will conduct or fund, up to the Licensee's Commitment, adult counts at fish ladders in the initial three-year period of operation. Pursuant to Adaptive Management protocols, if salmon and steelhead populations are insufficient to affirm ladder effectiveness under continuous duty, Licensee will conduct or fund adult counts at fish ladders for a longer period of time to be determined by mutual agreement per protocols.
(2) Resource Agencies will, subject to available funds, conduct or fund or seek funding for other monitoring and data assessments.

III.A.3. Habitat Objectives

Four Adaptive Management objectives specifically address fish habitat in an effort to measure the progress toward the AMP goal of restoring Chinook salmon and steelhead populations to the point they are viable and fully utilizing ecosystem carrying capacity. All four of these objectives are designed, in part, to adaptively manage the flows prescribed by the MOU. These flows were determined through careful analysis and Consensus, and are considered the best scientific estimate of biologically optimum flows. Hence, these flows are at an excellent level for salmon and steelhead restoration, are likely better for restoration than flows set through a strictly regulatory process, are considered to be insurance against future uncertainty, and are not intended to be adjusted experimentally.

As noted in the discussion of response limits above, response limits for the instream flows needs of salmon and steelhead are impossible to predict because of unforeseeable changes in the policies or methodologies that will be used to determine them, because of potential conflicts between project goals and unforeseeable trigger events, and because it is impossible to prejudge Consensus in future decision making. Therefore, any Adaptive Management instream flow levels response will be made provided that Consensus is reached among the Parties, to the extent funding is available from the WAF, AMF, Licensee commitment, and other Adaptive Management funds. If Consensus is not met, minimum instream flow changes will be determined via the dispute resolution process (see Section III.D.11).

Field observations were conducted per MOU Attachment 2 to determine the feasibility for establishing a threshold criteria of flow and stage above which Ramping Rates will not be required in Battle Creek. Field observations by fisheries biologists from CDFG and PG&E and by a USBR contractor were conducted in the spring of 2000 (CDFG 2001). Initially, areas of potential stranding habitat were identified by aerial surveys of the North and South Forks of Battle Creek in the Restoration Project Area. Several sites with significant potential for fish stranding due to flow fluctuations (e.g., large, low-gradient, in-channel gravel bars or bedrock areas, or side-channels, that could be de-watered during flow changes) were identified on the South Fork, while such sites were relatively rare on the North Fork.

A test flow change was analyzed at one South Fork site with relatively high stranding potential. Based on field observations, it was determined that ramping-related fish stranding would be avoided at flows greater than 460 cfs. These flows fill the South Fork channel sufficiently to inundate all potential stranding habitat. Rapid instream flow reductions at flows less than 460 cfs may dewater potential stranding habitat. Therefore, Ramping Rate criteria developed in this AMP would apply in the South Fork at flows less than 460 cfs, but would not apply at flows greater that this threshold.

At the time of this AMP publication, field observations of the relationship between flow changes and potential stranding habitat in the North Fork had not been completed.. However, the general channel morphology of the North Fork, consisting of steep-sided canyon walls, indicates that a threshold flow for initiating a Ramping Rate would be much less than that of the South Fork, which flows in a less incised canyon.

III.A.3.a. Habitat Quantity - Volume

The quantity of fish habitat as affected by instream flow levels may be a limiting factor of all life stages of all anadromous salmonids in Battle Creek (Conceptual Model 1). While the quantity of fish habitat as affected by instream flow levels has a direct effect on all life stages, depending on reach and month, the best available information for Chinook salmon suggests that spawning habitat is often the most limiting habitat while juvenile rearing habitat can also be limiting at times in some locations (Ward and Kier 1999a). Fry habitat has not been identified as a limiting factor for Chinook salmon in any reach. No specific life stages of steelhead could be identified as limited by flow though it is believed that greater instream flow levels could support more of both Chinook salmon and steelhead than exists at present (Conceptual Model 3).

The Battle Creek Salmon and Steelhead Restoration Project will adaptively manage the quantity of fish habitat in Battle Creek by adjusting instream flows released from diversion dams (Table 2). Initial instream flow levels set under the Restoration Project were based on levels believed to generally provide 95 percent of the maximum WUA, as derived from PHABSIM modeling, and as balanced by the flow needs of competing life stages (e.g. fish passage, prevention of redd dewatering; Ward and Kier 1999a).

Several uncertainties have been identified which could confound the Adaptive Management of instream flows in Battle Creek (Table 3). Individual key uncertainties can be summarized as uncertainties within: instream flow/habitat quantity model predictions and input data, and climate change (Figure 8). The relatively large number of uncertainties not considered to be “key” suggests that a broad focus should be maintained when confronting unexpected results in the Adaptive Management of instream flows in Battle Creek.

Habitat quantity, fish use of habitat, and advancements of science or modeling of instream flows will be monitored and analyzed as summarized in (Figure 8) and as described in detail in Habitat Objective 1 (Table 17). Climate and hydrology will be monitored as part of Habitat Objective 2 (Table 18). Monitoring under this objective is expected to continue for the term of the AMP.

If significant advancements in the science or modeling of fish habitat quantity resulting from changes in instream flow releases, these advancements will be incorporated into flow management. If observed fish habitat use does not match expectations, verification studies will be conducted, new habitat suitability criteria may be developed, and changes to instream flows may be recommended (Figure 8).

Habitat Quantity/Instream Flow Adaptive Management Model

(see Table 3; Concept Models 1, 2, 3; and Habitat Objectives 1)

Factors Affecting Habitat Quantity - Volume

-- Instream flow releases from diversion dams (controllable)

-- Unusually high flows (uncontrollable)

Species/Life Stages Affected

-- All life stages of all species; varies by month and by stream reach

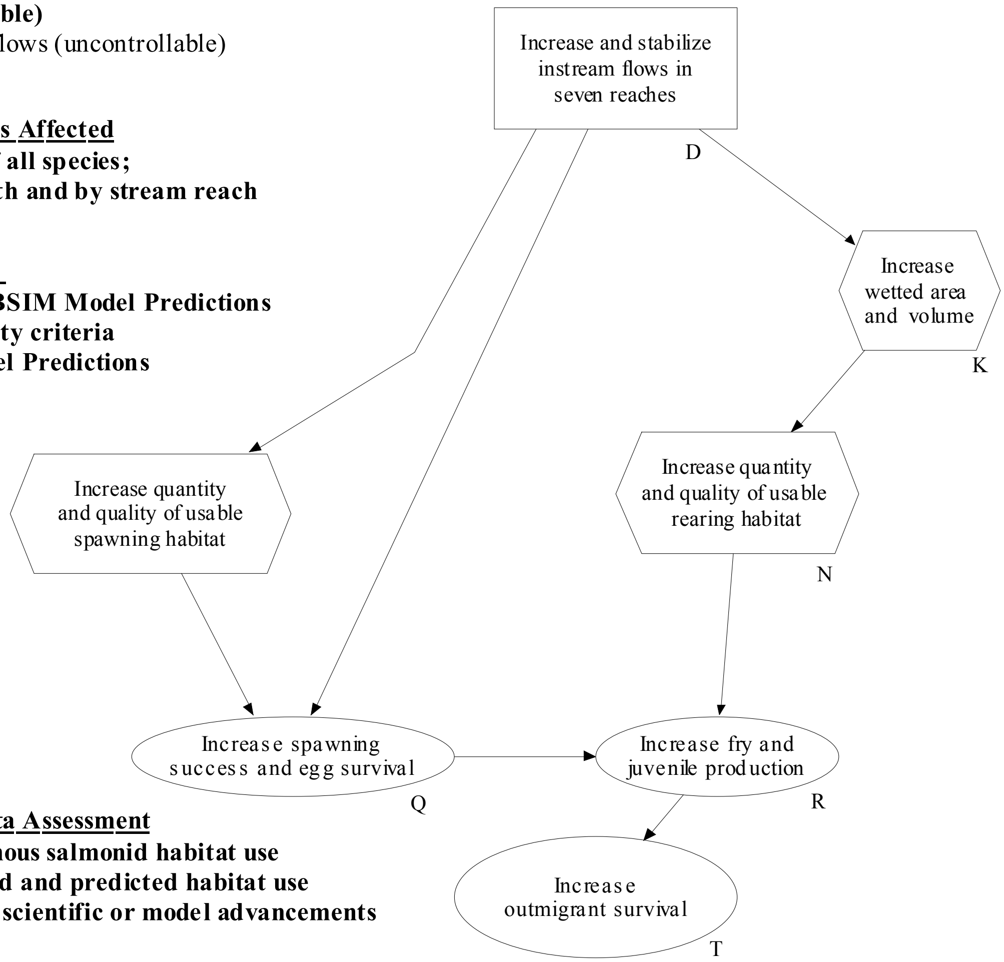
Key Uncertainties

? IFIM and PHABSIM Model Predictions

? Habitat suitability criteria

? Hydrology Model Predictions

? Climate Change



Monitoring and Data Assessment

– Monitor anadromous salmonid habitat use

– Compare observed and predicted habitat use

– Apply significant scientific or model advancements

Timeline

-- Apply significant scientific or model advancements as they become available

-- Apply habitat use data as accumulated

Trigger and Response

-- If significant advancements arise then incorporate advancements.

-- If observed habitat use does not match expectations, then conduct verification study and possibly develop new habitat suitability criteria and recommend changing instream flows.

Figure 8. Habitat Quantity/Instream Flow Adaptive Management Model

Table 17. Habitat Objective 1 – habitat quantity/instream flow.

HABITAT OBJECTIVE 1

Maximize usable habitat quantity – volume.

HYPOTHESIS: Implementation of instream flow levels specified in the description of the Restoration Project, and implementation of any adaptive responses affecting instream flows, will provide at least 95% of maximum usable habitat quantity for critical life stages among priority species.

MONITORING AND DATA ASSESSMENT APPROACH: (1) Compare observations with expected habitat use once there is enough salmon and steelhead to use available areas; (2) Observe and record anadromous salmonid habitat use during the course of other monitoring studies (e.g. snorkel surveys, radiotelemetry study; stream surveys); (3) Apply any appropriate advancements or refinements that significantly reduce uncertainty in flow/habitat relationships; (4) examine flow monitoring measurements taken immediately below each dam for the Facilities Monitoring Plan.

TIMELINE: (1) Apply appropriate, significant advancements in instream flow analysis as they become available; (2) Apply appropriate habitat use data as it is accumulated.

TRIGGER EVENT: (1) Significant advancements or refinements arise that reduce uncertainty in flow/habitat relationships and indicate that changes to instream flows are needed; (2) Observed habitat use is not consistent with expected habitat use at a time when there are enough salmon and steelhead to get a reliable data set.

RESPONSE: (1) Incorporate significant advancements or refinements into existing or new instream flow models, (2) If observations of habitat use are not consistent with expected habitat use, conduct a verification study of anadromous salmonid habitat use according to Contemporary protocols; (3) If suggested by the verification study, develop new habitat suitability criteria; (4) Recommend changing instream flows as appropriate consistent with MOU and FERC protocols.

RESPONSE LIMITS: All minimum instream flow changes deemed feasible, practical, reasonable, prudent, acceptable to the local community, and consistent with MOU and FERC protocols, will be implemented, provided that Consensus has been reached among the Parties and dedicated funding is available. If Consensus has not been reached, minimum flow changes will be determined through the dispute resolution process.

RESPONSE EVALUATION: Per standard response evaluation described above.

END POINT: None.

REPORTING: Per standard data management and reporting procedures described in sections III.D.7 and III.D.8.b

RESPONSIBILITY/FUNDING: Resource Agencies will, subject to available funds, conduct or fund or seek funding for data collection and report preparation. Other programs (e.g., CVPIA and CALFED) would be solicited to fund additional Diagnostic assessment tools to design a proper response (e.g., instream flow modeling). Water acquisition would be funded by the WAF, and AMF upon exhaustion of WAF. If both funds are exhausted and Consensus is reached, the Licensee funds Water Acquisition up to the Licensee's Commitment. If both funds are exhausted and Consensus is not reached, funding of minimum instream flows will be determined through the dispute resolution process, up to the Licensee's Commitment.

III.A.3.b. Water Temperature

Warm water temperatures in Battle Creek may be a limiting factor during June through September and may affect upstream migration of adult spring- and fall-run Chinook salmon and possibly late-arriving winter-run Chinook or early arriving steelhead; spawning of winter-run Chinook and spring-run Chinook; fry/juvenile production of winter- and late-fall run Chinook and steelhead; and outmigrating fall- and late-fall Chinook and steelhead (Conceptual Model 1). In turn, water temperature in Battle Creek may be affected by several factors including controllable streamflow and releases from cold springs, and uncontrollable hyporheic connections, climate, solar radiation, vegetative shading, and topographic shading (Figure 9). Water temperature goals and predictions were based on the use of the SNTEMP water temperature model (Tu 2001, TRPA 1998d), Contemporary flow, climate and water temperature conditions, and thermal criteria for Chinook and steelhead from near-by populations (Conceptual Model 3).

The Battle Creek Salmon and Steelhead Restoration Project will manage water temperature in Battle Creek by increasing instream flows and the release of cold spring water to the natural stream channel. (Table 2).

Several uncertainties have been identified which could confound the Adaptive Management of water temperatures in Battle Creek (Table 3). Individual key uncertainties can be summarized as uncertainties within: water temperature model predictions, climate change, and the effects of water temperature on spawning success, egg survival, juvenile production, and outmigrant success (Figure 9).

Water temperature and other elements of these key uncertainties will be monitored and analyzed as summarized in (Figure 9) and as described in detail in Habitat Objective 2 (Table 18). Features that will be monitored within Habitat Objective 2 include climate, longitudinal temperature regime, releases from cold springs, and, as part of Population Objective 1 (Table 13), spawner timing, redd distribution, juvenile production, and outmigrant condition factor. System-wide temperature regimes and climate will be monitored for at least five years including at least one year that has dry/hot conditions. Key water temperature monitoring stations will be maintained for the term of the AMP. Actual water temperatures and predicted water temperature goals will be compared.

If predicted water temperature goals are not attained as expected, Adaptive Management responses may be implemented which include remodeling of water temperatures using Contemporary models, development of a rule-based plan for modifying water temperatures, and increasing streamflows or spring releases as needed per Habitat Objective 2 (Table 18).

Water Temperature Adaptive Management Model

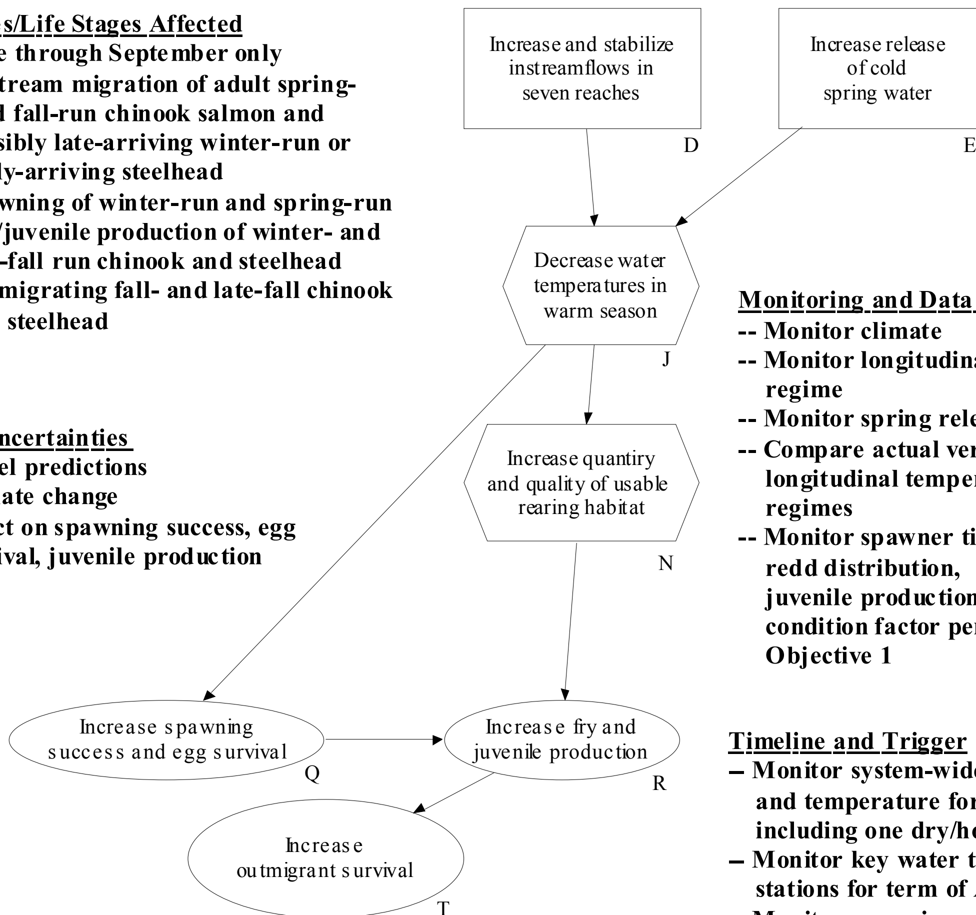
(see Table 3; Concept Models 1, 2, 3; and Habitat Objective 1)

<u>Factors Affecting Water Temperature</u>

– Streamflow (controllable, node D)
– Release of coldspring water (node E)
– Climate (uncontrollable)
-- Solar radiation (uncontrollable)
-- Topographic shading (uncontrollable)

<u>Species/Life Stages Affected</u>

– June through September only
– Upstream migration of adult spring- and fall-run chinook salmon and possibly late-arriving winter-run or early-arriving steelhead
– Spawning of winter-run and spring-run
– Fry/juvenile production of winter- and late-fall run chinook and steelhead
– Outmigrating fall- and late-fall chinook and steelhead



<u>Key Uncertainties</u>

? Model predictions
? Climate change
? Affect on spawning success, egg survival, juvenile production

<u>Monitoring and Data Assessment</u>

-- Monitor climate
-- Monitor longitudinal temperature regime
-- Monitor spring releases
-- Compare actual versus predicted longitudinal temperature regimes
-- Monitor spawner timing, redd distribution, juvenile production, outmigrant condition factor per Population Objective 1

<u>Timeline and Trigger</u>

– Monitor system-wide climate and temperature for 5 years including one dry/hot year
– Monitor key water temperature stations for term of AMP
– Monitor spawning and juvenile production per Population Objective 1
– If site/time specific temperature goals are not met, implement response

<u>Response</u>

1) Re-model water temperature
2) Develop rule-based plan
3) Increase streamflow/spring release as needed

Figure 9. Water Temperature Adaptive Management Model

Table 18. Habitat Objective 2 – water temperature.

HABITAT OBJECTIVE 2

Maximize usable habitat quantity – water temperature.

HYPOTHESIS: Implementation of instream flow levels and facilities modifications specified in the description of the Restoration Project, and implementation of any adaptive responses affecting instream flows or hydroelectric project facilities, will provide instream water temperatures that are suitable for critical life stages among species at appropriate stream reaches.

MONITORING AND DATA ASSESSMENT APPROACH: (1) Monitor climatic conditions within the South Fork watershed by establishing an appropriate weather station to support water temperature modeling efforts; (2) Monitor longitudinal water temperature regime of stream to determine attainability of water temperature goals[33] for each stream reach; (3) CDFG will monitor any springs to which it has conservation water rights; (4) Compare longitudinal water temperature regime with target points within the stream; (5) Compare monitoring results with predictions from the best available Contemporary water temperature models applied to appropriate stream reaches.

TIMELINE: (1) Monitor climatic and longitudinal water temperature regime for at least five years for system-wide water temperature monitoring including at least at least one year of dry/hot conditions; (2) Maintain key water temperature monitoring stations at appropriate locations for the term of the AMP.

TRIGGER EVENT: Water temperature goals are not attained in specific reaches under climatic conditions when attainment is expected.

RESPONSE: (1) Apply the best available Contemporary water temperature model to determine if water temperature goals could be met or exceeded under different climatic conditions by changing instream flows or spring releases from hydroelectric project water collection facilities; (2) If so indicated by the model, develop a rule-based plan[34] for short-term changes in the flows to reduce water temperatures to target ranges during hot weather[35], and perform a verification test of project operations according to the rule-based plan to determine if water temperature goals could be achieved; (3) Acquire water or spring releases from hydroelectric project water collection facilities to increase instream flows as needed.

RESPONSE LIMITS: All instream flow changes for water temperature adjustment deemed feasible, practical, reasonable, prudent, acceptable to the local community, and consistent with MOU and FERC protocols, will be implemented, provided that Consensus has been reached among the Parties and dedicated funding is available. If Consensus has not been reached, instream flow changes for water temperature adjustment will be determined through the dispute resolution process.

RESPONSE EVALUATION: Per standard response evaluation described above.

END POINT: (1) Monitoring the longitudinal water temperature regime would end after the AMTT determines the attainability of water temperature goals for each stream reach; (2) Prescriptive actions under the rule-based plan for selected water temperature target points would remain in effect for the term of the AMP; (3) There is no end point for key water temperature monitoring stations.

REPORTING: Per standard data management and reporting procedures described in sections III.D.7 and III.D.8.b. The annual Adaptive Management report will summarize all data collected under these monitoring and data assessment approaches and will present analyses required herein during the development of the rule-based plan and during implementation of the rule-based plan. Periodic updates of summarized raw data will be made to match the frequency of meetings of the AMTT.

RESPONSIBILITY/FUNDING: Resource Agencies will, subject to available funds, conduct or fund or seek funding sources other than Licensee for water temperature and climatic data collection. Other programs (e.g., CVPIA and CALFED) would be solicited to fund additional Diagnostic assessment tools to design a proper response (e.g., water temperature modeling). Water acquisition would be funded by the WAF, and AMF upon exhaustion of WAF. If both funds are exhausted and Consensus is reached, the Licensee funds Water Acquisition up to the Licensee's Commitment. If both funds are exhausted and Consensus is not reached, funding of Water Acquisition will be determined through the dispute resolution process, up to the Licensee's Commitment.

[33] Specific temperature goals for each reach based on temperature criteria and geographic prioritization are described in the *Battle Creek Salmon and Steelhead Restoration Plan*. The post-Restoration Project operations will be monitored to examine attainability under different controllable factors. Water temperature monitoring locations will include, at least, the start and end of each stream reach (including diversion reaches and Panther and Keswick reaches downstream of the limit of anadromous fish distribution), major spring water sources and tributaries, the terminus of canals or power house tailraces as needed, and as needed elsewhere.

[34] The rule-based plan would provide hydroelectric project operators with a predictive model that would allow them to adjust flow for the next day based on the current day's observed water temperatures and other variables. This rule-based plan will consider geographical limits or the attainability of temperature criteria, it will contain an allowance for deviations from criteria, and it will contain enough flexibility to cope with contingencies. This rule-

III.A.3.c. False Attraction

The potential false attraction of North Fork-origin adult salmon and steelhead to unsuitable habitat in the South Fork may be a limiting factor affecting upstream migration, holding, and spawning (Conceptual Model 1). Such false attraction may occur because salmonids "home" to natal spawning areas by water-born olfactory cues. The existing hydroelectric project continuously releases large quantities of North Fork water to the South Fork which may falsely attract North Fork fish to the South Fork. During times when total runoff is less than the diversion capacity of the hydroelectric project, the flow in the South Fork channel is comprised of about twice as much North Fork water as it does South Fork water. At present, holding and spawning habitat in the South Fork in the vicinity of these discharges is unstable and potentially unsuitable for survival or successful spawning. Therefore, the discharge of North Fork water to the South Fork may attract spawning salmonids to unsuitable habitat, and away from suitable habitat, thereby reducing spawning success and egg survival.[36]

The Battle Creek Salmon and Steelhead Restoration Project will guard against false attraction by modifying water conveyance facilities so that no North Fork water will be intentionally discharged into the South Fork (Table 2). Also, implementation measures within the Facilities Monitoring Plan will minimize the amount of North Fork water which might unintentionally be discharged into the South Fork (e.g. from system leaks or spills during system outages).

The key uncertainty is whether the facility modifications and implementation measures will be sufficient to avoid false attraction. Adult salmon and steelhead may still respond to leakages or short-term discharges during system outages (Table 3).

Water conveyance system leakage and discharges, and potential responses to leakage or discharge by salmon or steelhead, will be monitored and analyzed as summarized in Figure 10 and as described in detail in Habitat Objective 3 (Table 19).

If direct evidence of an adverse fish response to leakages or discharges from the hydroelectric project is observed, or if facilities monitoring identifies significant discharges from the water conveyance system, actions will be taken to restore the isolation of water in the conveyance system from the South Fork of Battle Creek (Table 19).

---

based plan would be developed based on established temperature protocols such as the NOAA Fisheries draft temperature guidelines.

[35] There may be a need to balance temperature control with other habitat effects of flow changes, but based on action priorities developed herein, temperature control may take priority over other habitat effects.

[36] Under a different scenario, even short-duration system outages which will result in the discharge of North Fork water into South Fork and which are designated to occur annually between February 1 and April 30 after implementation of the Restoration Project, may be long enough for juvenile fish in the South Fork to imprint on a confusing mix of North and South Fork water. If so imprinted, the returning adults could be confused at the forks when migrating upstream. However, if these South Fork fish made the incorrect choice and went up the North Fork, they would not likely encounter dangerous habitat conditions as would North Fork fish incorrectly choosing the South Fork. The period of time during a juvenile salmonid's life history when imprinting occurs is generally unknown but is believed to be a brief period, possibly near the end of their time spent in their natal habitat. The runs of fish which will be in their juvenile life stage during the period of planned outages include winter-, spring-, and fall-run Chinook, and steelhead. Only the youngest late-fall Chinook juveniles would occur in Battle Creek during the outage period. Adaptive adjustment of the timing of outages may occur within the February 1 and April 30 to optimize benefits to target populations.

False Attraction Adaptive Management Model

(see Table 3; Concept Models 1, 2, 3; and Habitat Objective 2)

Factors Affecting False Attraction

-- Salmonids "home" to natal spawning areas by water-borne olfactory cues

-- Existing hydroelectric project releases North Fork water to South Fork; possibly attracting N.F. fish to the S.F.

-- N.F. water is intentionally discharged at present to S.F at South and Inskip Powerhouses

-- Post-project discharge of N.F. water to S.F. from water conveyance system may inadvertently occur as a result of leakage from system or at spillways

Species/Life Stages Affected

-- Adult chinook salmon and steelhead; during upstream migration, holding, and/or spawning

Monitoring and Data Assessment

-- Monitor fish response to leakage

-- Monitor significant release or discharge from conveyance system

-- Measure leakage

-- Assess volume of leakage

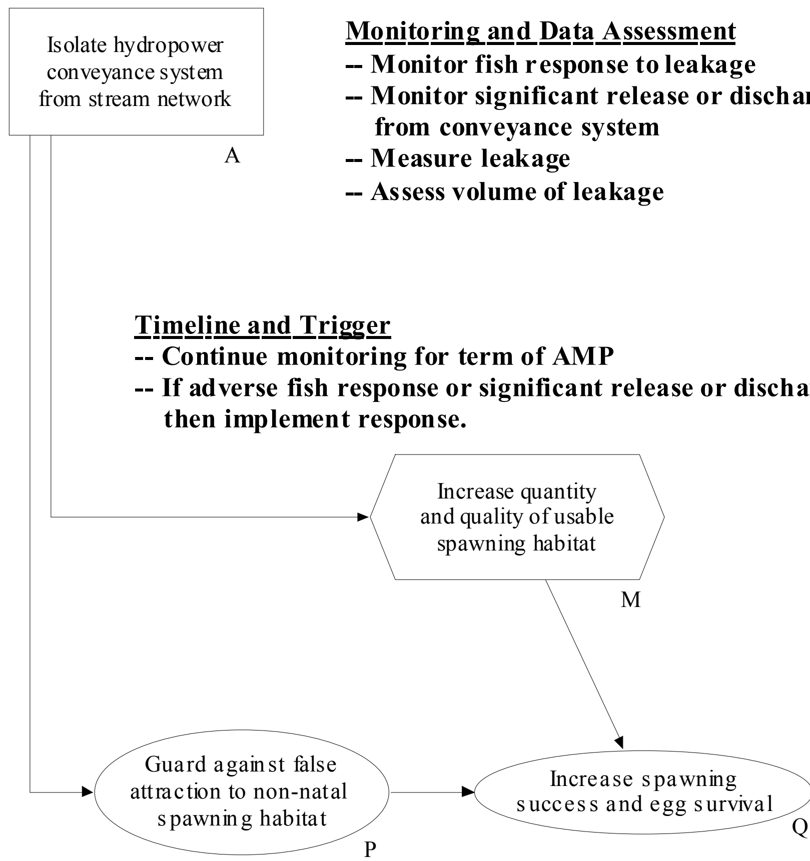
Key Uncertainties

? Will facility modifications guard against false attracton

Timeline and Trigger

-- Continue monitoring for term of AMP

-- If adverse fish response or significant release or discharge, then implement response.



Response

Restore isolation of water in conveyance sytem from South Fork

Figure 10. False Attraction Adaptive Management Model.

Table 19. Habitat Objective 3 – false attraction.

HABITAT OBJECTIVE 3

Minimize false attraction and harmful fluctuation in thermal and flow regimes due to planned outages or detectable leaks from the hydroelectric project.[37]

HYPOTHESIS: Implementation of facilities modifications specified in the description of the Restoration Project, implementation of the Facilities Monitoring Plan, and implementation of any adaptive responses affecting instream flows or hydroelectric project facilities, will ensure that water discharges from the powerhouse tailrace connectors or water conveyance system are confined to times and amounts that avoid false attraction.

MONITORING AND DATA ASSESSMENT APPROACH: (1) During the course of all other monitoring studies (e.g. radiotelemetry study, snorkel surveys, stream surveys), determine if salmon or steelhead appear to be responding to leakage from powerhouse tailrace connectors or discharges from the water conveyance system; (2) If salmon or steelhead appear to be responding to leakage from powerhouse tailrace connectors or discharges from the water conveyance system, (a) measure leakage or discharges using appropriate methodologies considering the size of the discharge, and (b) compare volume of leakage or discharge to streamflow at all times it is known to occur.

TIMELINE: Continue monitoring and data assessment approaches for the term of the AMP.

TRIGGER EVENT: (1) Direct evidence of an adverse fish response to leakages or discharges from the hydroelectric project is observed; (2) Facilities monitoring identifies and estimates significant intentional or unintentional release from the powerhouse tailrace connectors or discharge from the water conveyance system to the South Fork.

RESPONSE: Restore isolation of water in the powerhouse tailrace connectors or water conveyance system from the South Fork of Battle Creek.

RESPONSE LIMITS: Restore isolation to the extent that it is practical and feasible by Contemporary engineering practices for water conveyance structures provided that actions do not threaten the safety of the water conveyance system and dedicated funding is available.

RESPONSE EVALUATION: Per standard response evaluation described above.

END POINT: None

REPORTING: Per the Facilities Monitoring Plan. Per standard data management procedures described in section III.D.7.

RESPONSIBILITY/FUNDING: Installation costs of new/additional facilities required to meet Contemporary criteria or modification of existing facilities to avoid fish injury or mortality would be paid by AMF protocols. However, in the event that the AMF is exhausted, the Licensee will pay up to the Licensee's Commitment for Authorized Modifications to project facilities which are determined to be necessary under Adaptive Management. (1) Licensee conducts or funds the facilities monitoring consistent with the Facilities Monitoring Plan, including recording the timing and estimated amounts of water released from the canal gates and spill channels during known releases from the conveyance system; (2) Resource Agencies will, subject to available funds, conduct or fund or seek funding sources other than the Licensee for relevant biological monitoring and measurement of any unintentional leakage or discharge that elicits a response from salmon or steelhead.

[37] Planned outages from the powerhouse tailrace connectors or water conveyance system to the South Fork will occur during the period from February 1 through April 30, as specified in the MOU, and will be monitored per the Facilities Monitoring Plan. Forced outages are not covered under this AMP because they are assumed to occur infrequently and under emergency situations, and produce discharges of relatively short duration. In the event that these assumptions are not met, this objective could be modified to include forced outages. Emergencies are addressed in the AMP protocol section.

III.A.3.d. Fish Stranding and Isolation due to Flow Fluctuations/Ramping

The potential stranding or isolation of fish or redds may be a limiting factor affecting juvenile rearing and spawning (Conceptual Model 1). Fish stranding or isolation, including the dewatering of redds, may occur after planned or unplanned hydroelectric project outages when the project resumes diverting water from the stream. As the volume of water in the stream is quickly reduced (known as “ramping”), fish may be stranded or isolated from the main channel, in particular habitats, and may suffer mortality. The Battle Creek Salmon and Steelhead Restoration Project will manage against fish stranding or isolation by instituting conservative Ramping Rates at flows less than field-tested threshold flows.

One uncertainty has been identified to characterize this Adaptive Management element: will the combination of Ramping Rates and threshold flows be sufficient to protect salmon and steelhead (Table 3). However, this uncertainty is not considered “key” because the threshold flow was determined at the site most susceptible to stranding in the entire Project Area, conservative methods were used for determining Ramping Rates, and ramping will only occur infrequent as this hydroelectric project is not a peaking project.

None-the-less, biologically significant stranding or isolation could occur. Therefore, Habitat Objective 4 includes several monitoring components (Table 20) as summarized in Figure 12. Threshold flows in the North and South Forks will be evaluated and diagnosed. Ramping rates and these thresholds will be monitored during scheduled outages, although all available information suggests that the low uncertainty and risk associated with post-project ramping does not warrant the design of specific studies for this monitoring task prior to Restoration Project implementation.. Natural flow fluctuations may be monitored if necessary for comparisons between natural and project-related ramping effects. Evident fish stranding will be monitored throughout the term of the AMP. Depending on the particular trigger and outcome of Diagnostic studies, more appropriate Ramping Rates or threshold flows may be recommended as an Adaptive Management response.

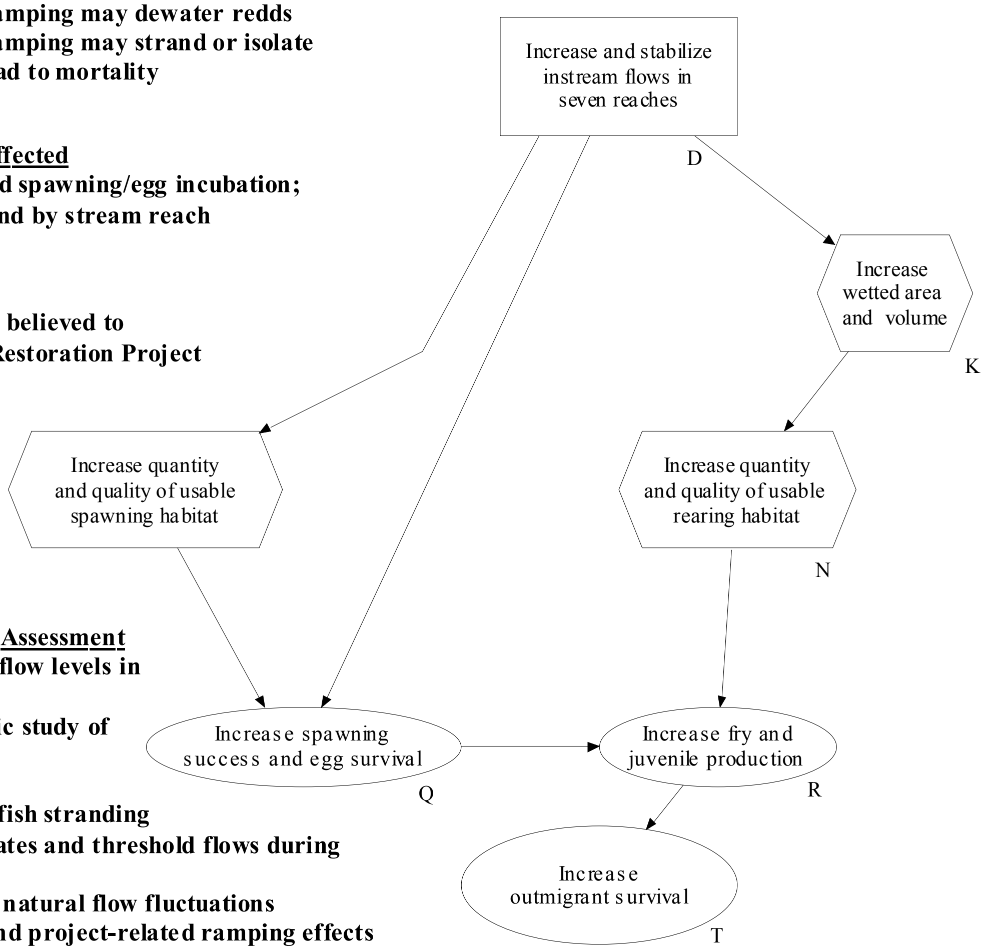
Ramping Rate Adaptive Management Model

(see Table 3; Concept Models 1, 2, 3; and Habitat Objectives 4)

<u>Factors Affecting Fish Stranding/Isolation</u>
-- Flow fluctuations/ramping may dewater redds
-- Flow fluctuations/ramping may strand or isolate juvenile fish and lead to mortality

<u>Species/Life Stages Affected</u>
-- Juvenile rearing and spawning/egg incubation; varies by month and by stream reach

<u>Key Uncertainties</u>
? no uncertainties are believed to threaten success of Restoration Project



<u>Monitoring and Data Assessment</u>
-- Evaluate threshold flow levels in South Fork
-- Conduct a diagnostic study of ramping thresholds in North Fork
-- Collect evidence of fish stranding
-- Monitor ramping rates and threshold flows during scheduled outages
-- Potentially monitor natural flow fluctuations
-- Compare natural and project-related ramping effects

<u>Timeline</u>
-- North Fork diagnostic study will be completedas soon as possible, possibly in spring 2004.
-- Fish stranding will be monitored for term of AMP
-- Other monitoring to be conducted when applicable

<u>Trigger and Response</u>
-- If project-induced, biologically significant stranding or isolation is observed, then evaluate natural stranding and isolation, conduct a diagnostic assessment of ramping effects using statistically valid techniques, compare project-induced ramping with natural flow fluctuations and recommend a more appropriate Ramping Rate.

Figure 12. Ramping rate adaptive management model.

Table 20. Habitat Objective 4 – Stranding, isolation, Ramping Rates and flow fluctuations.

HABITAT OBJECTIVE 4 **Minimize stranding or isolation of salmon and steelhead due to variations in flow regimes caused by hydroelectric project operations.**
HYPOTHESIS: Implementation of facilities modifications specified in the description of the Restoration Project, implementation of the Facilities Monitoring Plan, and implementation of any adaptive responses affecting instream flows or hydroelectric project facilities, will ensure that variations in flow regimes, following forced or scheduled outages where the available diversion flow has been released to the natural stream channel, do not strand salmon and steelhead or isolate them from their habitat when diversions are resumed.
MONITORING AND DATA ASSESSMENT APPROACH: (1) In the course of other monitoring studies, evaluate, in the South Fork, threshold flow levels above which ramping-rates may differ from 0.1 feet/hour[38]; (2) In the North Fork, conduct a Diagnostic study of ramping thresholds to determine the flow level above which Ramping Rates may differ from 0.1 foot/hour; (3) Collect evidence of fish stranding during the course of all other monitoring studies (e.g. radiotelemetry study, snorkel surveys, stream surveys); (4) Monitor Ramping Rates and threshold flow levels during scheduled outages at appropriate sites to ascertain their effectiveness to avoid stranding or isolating anadromous fish from their preferred habitat[39]; (5) Monitor natural flow fluctuations not caused by project operations to ascertain their effect on stranding or isolating anadromous salmonids; (6) Compare the stranding effects of project-induced ramping and natural flow fluctuations; (7) Monitor streamflows in both forks of Battle Creek near their mouths to assess flow patterns.
TIMELINE: (1) The Diagnostic study of threshold flows in the North Fork will be completed the first time flow conditions are appropriate and may occur as early as spring 2001; (2) Evidence of fish stranding will be collected through the term of the AMP, (3) Monitoring of Ramping Rates will be conducted during scheduled outages; (4) Monitoring of natural flow fluctuations will be conducted the first time flow conditions are appropriate and may occur as early as spring 2001; (5) Comparisons of project-induced ramping and natural flow fluctuations will be completed as soon as flow conditions permit.
TRIGGER EVENT: Biologically significant salmon and steelhead stranding or isolation, caused by project-induced ramping and natural flow fluctuations, is observed.
RESPONSE: Conduct a Diagnostic assessment of ramping effects on anadromous salmonids at the 0.1 foot/hour rate specified in the MOU, or slower, that determines the relationship between stranding/ isolation and Ramping Rates using statistically valid techniques. The assessment would recommend a more appropriate Ramping Rate.
RESPONSE LIMITS: All instream flow changes for ramping deemed feasible, practical, reasonable, prudent, acceptable to the local community, and consistent with MOU and FERC protocols, will be implemented, provided that Consensus has been reached among the Parties. If Consensus has not been reached, instream flow changes for ramping will be determined through the dispute resolution process.
RESPONSE EVALUATION: Per standard response evaluation described above.
END POINT: Ramping Rate is finalized base on Diagnostic assessment Ramping Rate study or response evaluation.
REPORTING: Results from the Ramping Rate study will be incorporated into the annual Adaptive Management report. Other reporting and data management per standard data management and reporting procedures described in sections III.D.7 and III.D.8.b.
RESPONSIBILITY/FUNDING: (1) Resource Agencies will, subject to available funds, conduct or fund or seek funding for incidental monitoring and the Diagnostic Ramping Rate assessment; (2) Licensee will fund, up to the Licensee's Commitment, costs associated with more restrictive Ramping Rates, consistent with WAF and AMF protocols.[40]

[38] CDFG (2001) determined that 460 cfs is an adequate threshold flow below which Ramping Rates should be applied for the protection of salmon and steelhead downstream of Inskip Dam (and above which, Ramping Rates need not be applied) following the implementation of the Battle Creek Salmon and Steelhead Restoration Project.

[39] MOU Section 9.1A.2.(c); During drafting of this AMP, all available information suggested that the low uncertainty and risk associated with post-project ramping does not warrant the design of specific studies for this monitoring task prior to Restoration Project implementation.

[40] MOU Section 6.1.D and MOU Attachment 2

III.A.4. Passage Objectives

Three Adaptive Management objectives specifically address fish passage in an effort to measure the progress toward the AMP goal of restoring Chinook salmon and steelhead populations to the point they are viable and fully utilizing ecosystem carrying capacity. All three of these objectives are designed to adaptively manage the fish passage provisions in the MOU and facilities constructed as part of the Restoration Project. The design of these facilities was based on considerable fish passage engineering and biological experience and meet Contemporary criteria. Hence, these fish passage facilities and provisions are an excellent start for salmon and steelhead restoration and are considered to be insurance against future uncertainty.

III.A.4.a. Fish Ladders, Fish Screens, and Natural Barriers

Fish passage in Battle Creek may be a factor limiting juvenile and adult stages of salmon and steelhead (Conceptual Model 1). The presence of diversion dams within anadromous habitat and inadequate or inoperative fish ladders at these dams could affect the ability of spawners to reach suitable habitat. Natural barriers can have a similar effect as inoperative fish ladders. Also, the lack of operative fish screens at diversion dams within anadromous habitat pose significant risk of entrainment of especially juvenile fish into the hydroelectric project water conveyance system (Figure 13).

The Battle Creek Salmon and Steelhead Restoration Project will attempt to rectify these fish passage impediments in several ways (Table 2). Five existing diversion dams will be decommissioned, eliminating long-term fish passage questions at these sites. Potential short term fish passage uncertainties related to reservoir-stored sediment at these decommissioned dam sites will be addressed with specific construction and mitigation measures. Fish passage at remaining dams on the North Fork and South Fork Battle Creek within the Project Area will be addressed through the installation of Fail-Safe Fish Ladders and Fail-Safe Fish Screens. Fish passage at natural obstacles in the stream channel will be addresses by increasing and stabilizing instream flows in seven reaches of the Project Area.

Several uncertainties could confound the Adaptive Management of fish passage in Battle Creek. Individual key uncertainties can be summarized as uncertainties about models of fish passage at natural barriers and the applicability of older field data to existing conditions, and about the capability of fish ladders designed for the remaining dams to adequately provide fish passage. While uncertainties do qualify the assumption that Fail-Safe Fish Screens will adequately insure downstream passage of juveniles at dams, this uncertainty was not considered to be “key” because only a portion of juvenile populations may be exposed to fish screens and because literature on this topic is generally accepted and robust. Fish screening has repeatedly been shown to improve outmigrant survival to adequate levels as defined in MOU.

Fish passage and other elements of these uncertainties will be monitored and analyzed as summarized in (Figure 13) and as described in detail in Passage Objectives 1 through 3 (Table 21, Table 22, and Table 23). An initial Diagnostic study of adult salmon and steelhead using radiotelemetry (Section XII) will be the principal tool for assessing fish passage at fish ladders and potential natural barriers. The observed distribution of adult salmon and steelhead will complement the radiotelemetry study; this distribution will be compared to the expected distribution and the locations of fish ladders and potential barriers. Evidence of fish injury or congregations of fish at dams or below potential natural barriers will be particularly instructive, as will counts of adults passing through fish ladders, which will be conducted for at least three years after construction. Visual inspection of potential natural barriers for the term of the AMP will augment the assessments based on adult distribution as may Diagnostic studies when warranted. Key hydraulic parameters will be monitored at each fish ladder and fish screen for the term of the AMP and additional Diagnostic studies of hydraulics will be conducted at project startup and other times as the project ages. Possible fish entrainment into diversion canals will be visually assessed, especially at times when canals are dewatered.

Adaptive management responses, including additional Diagnostic studies, potential modification of fish ladders and fish screens, and potential modification of natural barriers physically or with flow releases, may be implemented if fish ladder or screen criteria changes, if facilities do not perform as designed, if fish injury or entrainment is evident, if adult spawner distribution is abnormal for three years, or if adult salmon or steelhead migration is impeded by natural barriers.

Fish Passage Adaptive Management Model

(see Table 3; Concept Models 1, 2, 3; and Passage Objectives 1, 2, and 3)

Factors Affecting Fish Passage

-- The presense of dams in anadromous habitat impedes sate upstream and downstream passage

-- Inadequate or inoperative fish ladders impede passage at dams

-- The lack of operable fish screens poses significant entrainment risk especially to juvenile fish

-- Natural obstacles may impede upstream fish passage at low instream flows

Species/Life Stages Affected

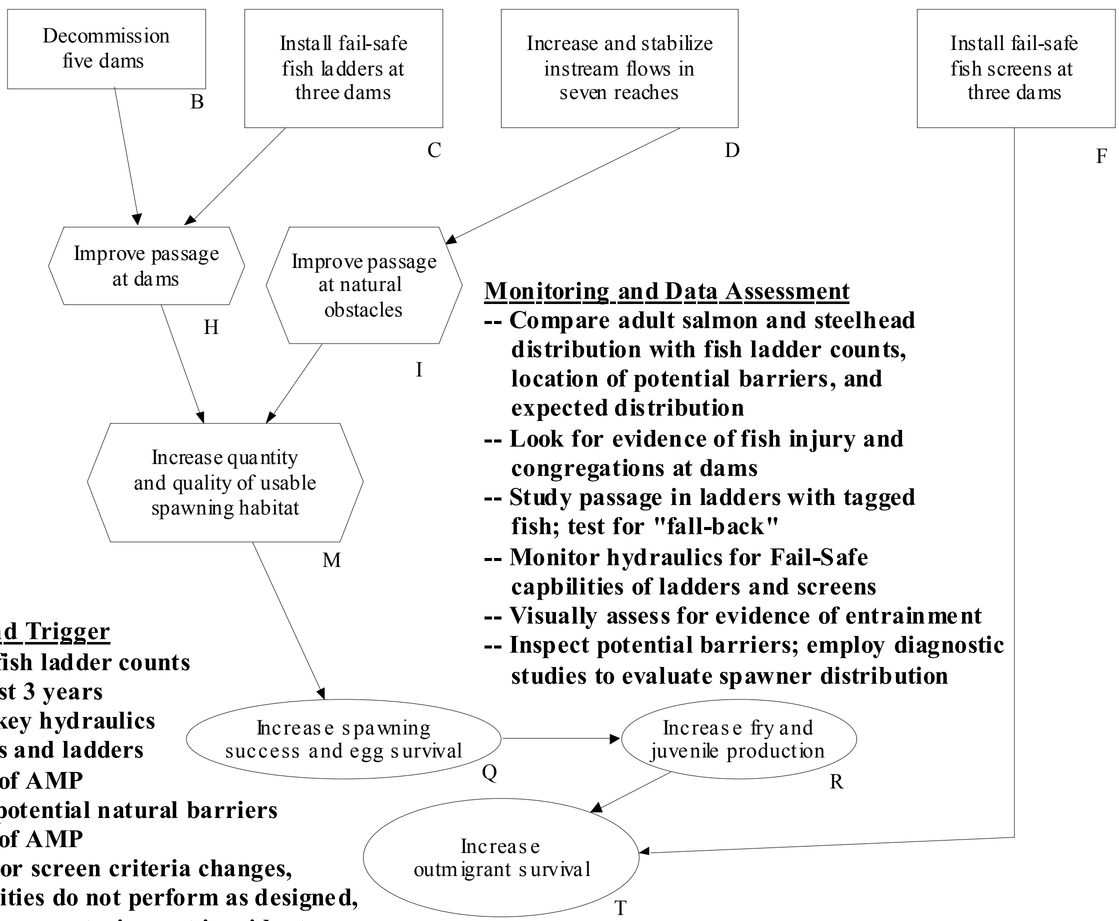
-- Adult and juvenile salmon and steelhead; varies by factor

Key Uncertainties

? Model predictions for natural barriers

? Field studies of natural barriers are old

? Will fish ladders provide adequate passage



Monitoring and Data Assessment

-- Compare adult salmon and steelhead distribution with fish ladder counts, location of potential barriers, and expected distribution

-- Look for evidence of fish injury and congregations at dams

-- Study passage in ladders with tagged fish; test for "fall-back"

-- Monitor hydraulics for Fail-Safe capbilities of ladders and screens

-- Visually assess for evidence of entrainment

-- Inspect potential barriers; employ diagnostic studies to evaluate spawner distribution

Timeline and Trigger

-- Monitor fish ladder counts for at least 3 years

-- Monitor key hydraulics at screens and ladders for term of AMP

-- Monitor potential natural barriers for term of AMP

-- If ladder or screen criteria changes, or if facilities do not perform as designed, or if injury or entrainment is evident, or if spawner distribution is abnormal for 3 years or if adult salmon/steelhead migration is impeded by natural obstacle, then implement responses.

Response

-- Varies according to trigger but includes diagnostic studies and potential modification of ladders or screens

-- Natural barriers may be physically modified or rectified with flow releases

Figure 13. Fish Passage Adaptive Management Model.

Table 21. Passage Objective 1 – fish ladders.

PASSAGE OBJECTIVE 1
Provide reliable upstream passage of salmon and steelhead adults at North Battle Creek Feeder, Eagle Canyon, and Inskip Diversion Dams per Contemporary engineering standards/guidelines.

HYPOTHESIS: Implementation of facilities modifications specified in the description of the Restoration Project, implementation of the Facilities Monitoring Plan, and implementation of any adaptive responses affecting instream flows or hydroelectric project facilities, will insure unimpeded passage of adult salmon and steelhead at fish ladders relative to Contemporary standards/guidelines.

MONITORING AND DATA ASSESSMENT APPROACH: (1) Use video or electronic counters in ladders to count anadromous salmonids; (2) Study fish passage at each ladder with a group of tagged test fish or radio tracking (Section XII); (3) Monitor the possible unintended downstream-return of upstream-migrating fish ("fall back") over or through diversion dams using tagged fish or radio tracking studies (Section XII); (4) Compare ladder counts with spawner distribution and predicted habitat use; (5) In the course of all other studies (e.g. radiotelemetry, snorkel surveys, stream surveys), look for direct evidence of fish injury related to upstream passage at fish ladders; (6) Make underwater observations for congregations of adults below the dam and compare to ladder counts; (7) Monitor key hydraulic parameters continuously for Fail-Safe capabilities according to long-term Operations and Maintenance Plan and Facility Monitoring Plan.

TIMELINE: (1) Monitor video or electronic counters for three years. Pursuant to Adaptive Management protocols, if salmon and steelhead populations are insufficient to affirm ladder effectiveness under continuous duty, video or electronic counting will be continued for a longer period of time by agreement of the Parties to be determined per protocols; (2) Conduct continuous monitoring of key hydraulic parameters for the term of the AMP.

TRIGGER EVENT: (1) Standards/guidelines, or Contemporary criteria, are changed and an evaluation of the existing ladder, according to Contemporary testing protocol, demonstrates a significant exceedence from the standards/guidelines/criteria; (2) Operations and maintenance activities indicate that facilities are not performing as designed; (3) Contemporary standards/guidelines, or future criteria, are not met, or there is direct evidence of impaired fish passage;[41] (4) Direct evidence of salmon or steelhead injury from passage through fish ladders is observed; (5) Absence of spawning adults of species expected to distribute themselves in the higher elevation reaches of the stream, based on all observational data at times when there are sufficient populations of salmon and steelhead to observe, are observed for at least three years when no other barriers are identified.

RESPONSE: (1) If triggered by a change in standards/guidelines/criteria, refer matter to AMPT to determine response; (2) If triggered by a failure to perform as designed, diagnose if there is direct evidence of impaired fish passage or injury; (3) If no direct evidence of impaired fish passage or injury, request a variance; (4) If triggered by unexpected spawner distribution (as defined in trigger event) then diagnose problem with appropriate tools such as tagged test fish or a radio tracking study; (5) If triggered by direct evidence of impaired fish passage or injury associated with fish ladders, diagnose reason for the problem and modify or replace fish ladder or components.

RESPONSE LIMITS: All actions deemed feasible, practical, reasonable, prudent, acceptable to the local community, and consistent with MOU and FERC protocols, will be implemented, provided that Consensus has been reached among the Parties and dedicated funding is available. If Consensus has not been reached, appropriate actions will be determined through the dispute resolution process. Major project changes in facilities (e.g., new dam site, dam removal, major facility changes) would be subject to the FERC decision-making process.

RESPONSE EVALUATION: Per standard response evaluation described above.

END POINT: Conclude ladder effectiveness monitoring after three years with sufficient salmon and steelhead populations and no identified fish passage problems at particular fish ladder. Continue operations and maintenance monitoring for the term of the AMP. Salmon and steelhead counts at the ladder may continue as needed for basin wide biological studies.

REPORTING: Per standard data management and reporting procedures described in sections III.D.7 and III.D.8.b.

RESPONSIBILITY/FUNDING: After transfer of facility from USBR to Licensee, Licensee assumes all costs for ladder repairs and replacements due to normal wear and tear, catastrophic damage, and any other type of damage, and will ensure that the ladders meet Fail-Safe criteria. Installation costs of new/additional facilities required to meet Contemporary criteria or modification of existing facilities to avoid fish injury or mortality would be paid by AMF protocols. However, in the event that the AMF is exhausted, the Licensee will pay up to the Licensee's Commitment for Authorized Modifications to project facilities and operations which are determined to be necessary under Adaptive Management. The following responsibilities also apply after transfer of the facility from USBR to Licensee. (1) Licensee will conduct or fund, up to the Licensee's Commitment, monitoring to ensure the effectiveness and continued reliable operation of ladders pursuant to the Facilities Monitoring Plan; (2) Continued monitoring specified as part of the Adaptive Management process would be funded according to Adaptive Management protocols; (3) Resource Agencies will, subject to available funds, conduct or fund or seek funding for biological monitoring using ladder counts after the ladder is deemed effective.

[41] Direct evidence of impaired fish passage could include, but is not limited to, evidence from radiotelemetry studies; persistent or repeated plugging of the ladder with debris or persistent, abnormally high concentrations of salmon and steelhead below dams combined with low ladder counts.

Table 22. Passage Objective 2—fish screens.

PASSAGE OBJECTIVE 2

Provide reliable downstream passage of juveniles at North Battle Creek Feeder, Eagle Canyon, and Inskip Diversion Dams per Contemporary criteria after the transfer of facilities to Licensee.

HYPOTHESIS: Implementation of facilities modifications specified in the description of the Restoration Project, implementation of the Facilities Monitoring Plan, and implementation of any adaptive responses affecting instream flows or hydroelectric project facilities, will ensure that hydraulic parameters at fish screens meet Contemporary criteria at all times.

MONITORING AND DATA ASSESSMENT APPROACH: (1) Properly calibrated remote sensing devices that continuously monitor water surface elevation differences on the inlet and outlet sides of screens will be operated to identify plugging[42] according to long-term Operations and Maintenance Plan and Facility Monitoring Plan, (2) Use Contemporary NOAA Fisheries criteria[43] or subsequent NOAA Fisheries approved criteria. As per p 73490 in NOAA Fisheries "4d Rule"; (3) Biological effectiveness of the screen relies on meeting Contemporary fish screen criteria as it has been affirmed to protect fish from injury and entrainment in applicable studies; (4) Measure, at various stream and diversion flows, hydraulic parameters such as approach and sweeping velocities, (5) Calculate flow rates for screen sections to verify approach and sweeping velocities; ; (6) Conduct visual observations of canals, during the course of other studies (e.g. any time field crews are near diversion points) and especially at times when canals are dewatered, to check for possible entrainment.

TIMELINE: (1) Conduct continuous monitoring of water surface elevation on both sides of the fish screen for the term of the AMP; (2) Measure all relevant hydraulic parameters such as such as approach and sweeping velocities and water surface elevations at startup, and other appropriate times and flows as the facility ages, per the long-term Operations and Maintenance Plan.

TRIGGER EVENT: (1) Abnormal water level or water level differential at screens is detected, (2) Contemporary fish screen criteria is changed and an evaluation of the existing screen, according to Contemporary testing protocol, demonstrates a significant exceedence from the criteria; (3) Operations and maintenance activities indicate that facilities are not performing as designed; (4) Contemporary criteria is not met, or there is evidence of fish entrainment or injury.

RESPONSE: (1) If triggered by detection of exceedence of critical water level differential, automatically close the associated canal diversion gate and trigger an alarm at operating headquarters to allow timely response to the suspect condition and closure of the associated canal intake gate,(2) If triggered by a change in NOAA Fisheries criteria, refer matter to AMPT to determine response; (3) If triggered by a failure to perform as designed, diagnose whether facility provides injury-free downstream passage of juvenile salmon and steelhead; (4) If facility provides injury-free downstream passage of juvenile salmon and steelhead, request a variance; (5) If evidence of fish entrainment or injury, diagnose reason for the problem and modify or replace fish screens or components.

RESPONSE LIMITS: All actions deemed feasible, practical, reasonable, prudent, acceptable to the local community, and consistent with MOU and FERC protocols, will be implemented, provided that Consensus has been reached among the Parties and dedicated funding is available. If Consensus has not been reached, appropriate actions will be determined through the dispute resolution process. Major project changes in facilities (e.g., new dam site, dam removal, major facility changes) would be subject to the FERC decision-making process.

RESPONSE EVALUATION: Per standard response evaluation described above.

END POINT: None.

REPORTING: Per standard data management and reporting procedures described in sections III.D.7 and III.D.8.b.

RESPONSIBILITY/FUNDING: The responsibility and funding of monitoring of key hydraulic parameters will be assigned in the Facilities Monitoring Plan. After transfer of facility from USBR to Licensee, Licensee assumes all costs for screen repairs and replacements due to normal wear and tear, catastrophic damage, and any other type of damage, and will ensure that the screens meet Fail-Safe criteria. Installation costs of new/additional facilities required to meet Contemporary criteria or modification of existing facilities to avoid fish injury or mortality would be paid by AMF protocols. However, in the event that the AMF is exhausted, the Licensee will pay up to the Licensee's Commitment for Authorized Modifications to project facilities and operations which are determined to be necessary under Adaptive Management.

[42] MOU 7.2.C

[43] For example, the Contemporary fish screening criteria used to generate this plan were adopted from NOAA Fisheries Southwest Region "Fish Screening Criteria For Anadromous Salmonids, January 1997."

Table 23. Passage Objective 3 – natural barriers.

PASSAGE OBJECTIVE 3

Provide reliable upstream passage of adult salmon and steelhead to their appropriate habitat over natural obstacles within the Restoration Project Area while maintaining an appropriate level of spatial separation among the runs.

HYPOTHESIS Implementation of instream flow levels and facilities modifications specified in the description of the Restoration Project, implementation of the Facilities Monitoring Plan, and implementation of any adaptive responses affecting instream flows or hydroelectric project facilities, will ensure that Natural instream barriers do not impede upstream migration of adult salmon and steelhead at prescribed flows and normal wet season flow regimes.

MONITORING AND DATA ASSESSMENT APPROACH: (1) Conduct a initial Diagnostic study of fish passage using radiotelemetry (Section XII); (2) Inspect potential barriers during annual surveys including photographic documentation and description; (3) Compare spawner distribution relative to suspected barriers; (4) Compare observed spawner distribution relative to expected spawner distribution for a particular species; and (5) Use Contemporary methodologies that consider flow regime to identify actual barriers;[44] and (6) Employ additional Diagnostic studies as needed (e.g., radio tracking) if observed spawning differs relative to expected spawning distribution but no specific barrier is identified.

TIMELINE: Conduct continuous monitoring of natural potential barriers for the term of the AMP.

TRIGGER EVENT: An obstacle in the Restoration Project Area is found to be unduly impeding adult salmon or steelhead migration under a range of flows including the prescribed instream flows.

RESPONSE: (1) Modify barrier, giving priority to those barriers that block large portions of a species' preferred habitat, while maintaining an appropriate level of spatial separation among the runs;[45] (2) If barrier cannot be modified either in the short term or long term, acquire water to change instream flows, if appropriate, to levels that allow passage over natural barriers for the necessary times only.

RESPONSE LIMITS: All instream flow changes for salmon and steelhead passage deemed feasible, practical, reasonable, prudent, acceptable to the local community, and that are consistent with MOU and FERC protocols, will be implemented, provided that Consensus has been reached among the Parties. If Consensus has not been reached, instream flow increases for salmon and steelhead passage will be determined through the dispute resolution process. If appropriate level of barrier modification is not feasible, flow changes would be set to levels that allow passage over natural barriers for the necessary times only. Long-term and medium-term instream flow increases over the estimated flows for maximum usable habitat will provide not less than 90 percent of the maximum usable habitat. Short-term, pulsed instream flows may be set to higher levels that provide less than 90 percent of the maximum useable habitat for short periods of time.

RESPONSE EVALUATION: Per standard response evaluation described above.

END POINT: None

REPORTING: Per standard data management and reporting procedures described in sections III.D.7 and III.D.8.b.

RESPONSIBILITY/FUNDING: (1) Resource Agencies will, subject to available funds, conduct or fund or seek funding sources other than the Licensee for monitoring activities; (2) Resource Agencies will, subject to available funds, conduct or fund or seek funding sources other than the AMF or the Licensee for modification of barriers; (3) Water acquisition for increased instream flows downstream of Inskip, North Battle Creek Feeder, and Eagle Canyon diversion dams to facilitate fish passage will be funded by the WAF, AMF, Licensee up to the Licensee's Commitment, or others.

[44] For example, TRPA (1989) methodologies for barrier determination were used to generate this plan.

[45] Natural barriers within streams can provide many important ecosystem functions including restricting the movement of introduced fishes, acting as selective factors in the natural evolution of species, and separating subpopulations of native fishes. For example, sympatric races of Chinook salmon generally segregate themselves by spawning at different times or in different locations within a stream. This spatial segregation is usually determined through interactions between flow and natural barriers. Removing some barriers could disrupt the natural factors controlling this natural segregation. For example, the spawning timing of spring-run Chinook and fall-run Chinook may overlap. However, spring-run typically migrate to spawning grounds at higher flows and may more easily pass obstacles at those flows. Spring-run Chinook could be put in unnatural contact with fall-run Chinook if barriers were removed which normally stop fall-run during the low-flow season. Because of the many benefits of natural barriers, caution and careful analysis will characterize any decisions to remove natural barriers under Adaptive Management.

III.B. Annual Monitoring

This section summarizes the many studies to be conducted as part of implementation of the Adaptive Management Objectives. More detail regarding the intent of an individual study and its role in Adaptive Management can be found in the objective table or tables noted for that study.

Some specific terms and abbreviations used in Table 25 are:

- CRR: Cohort Replacement Rate.
- Analysis: Evaluation of field data to assess of the Restoration Project. The field data for the analyses in Table 25 are often intended to be based on field data from multiple Battle Creek field studies, or on data from other monitoring programs (e.g. compare Battle Creek CRR to CRR of Reference Watersheds).
- Diagnostic field study: A field study of limited scope and duration that is designed to provide information necessary to improve our ability to distinguish between adaptive responses as described in Contemporary Objectives Tables (Section III.A).
- CBDA 1: The grant from the CBDA for implementation of the Battle Creek Fisheries Restoration Project. It is proposed that many of the studies presented in Table 25 will be funded in part under the current amended version of this grant proposal; however, because of a 3-year limitation in the encumbrance of CBDA funds for monitoring, virtually all of the Resource Agency Adaptive Management monitoring studies will require subsequent CBDA grants or funds from other public sources.
- CBDA: Indicates need for subsequent grants from the CBDA
- CVPIA: Central Valley Project Improvement Act. Some studies in Battle Creek are already in progress under funding from the CVPIA;
- Focused Studies: Studies that are of secondary importance to accomplishing the fisheries restoration goals of the project (e.g. Sediment Monitoring) or whose implementation is contingent on need or advances in analytical methods. Focused Studies may be conducted to take advantage of learning opportunities that arise in the course of Adaptive Management.

Table 25 provides the name of specific Adaptive Management monitoring tasks and the nature of the task (analysis, field study, Diagnostic study, Focused Study etc.); the "Objectives" column indicates the objective table that should be consulted for more explanation of the task and how it fits into the AMP. The "Responsibility" column notes the Parties implementing each task, as identified in the MOU that established the framework for the Restoration Project. The "Timeline" and "Estimated Annual Cost" columns represent the best estimates of the AMTT of the scope of individual tasks. All future cost estimates are provisions; the scope of future monitoring may change as a result of Adaptive Management decisions, advances in analytical procedures, or other unforeseen developments. In cases where multiple tasks are to be conducted as part of a specific study, the estimated annual cost for all the tasks is shown once, under the first line related to that effort, and costs for the related tasks refer to that line. The "Funding

Source" column identifies those task to be funded through the initial CBDA grant for implementation of the Battle Creek Fisheries Restoration Project.

III.C. Focused Studies

Tasks identified as "Focused Studies" are of either of secondary importance to accomplishing the fisheries restoration goals of the project (e.g. Riparian Studies, Sediment Monitoring) or whose implementation is contingent on need or advances in analytical methods (e.g. Apply advancements in flow/habitat relationships). Focused Studies may be conducted to take advantage of learning opportunities that arise in the course of Adaptive Management. Those tasks that are secondary to the fisheries goals are not described in the objective tables. More information on these tasks is provided in the following summaries and the appendices noted below. In cases where one or more Focused Studies are related to each other (e.g. Riparian and Sediment Focused Studies) or are related to AMP objectives (e.g. Cold-water Refuges and water temperature), knowledge learned in one study will be transferred to the other studies or objectives.

III.C.1. Sediment Monitoring Plan

A complete description of this study can be found in Section VII.

There is considerable uncertainty related to channel response following dam removal, especially in coarse-grained river environments. As such, there is significant learning potential related to pre- and post-dam sediment monitoring in the Battle Creek basin, despite the relatively modest volumes of sediment stored behind the dams slated for removal. Monitoring of coarse and fine sediment downstream of proposed dam removal sites has been designed to address *process-form* linkages, in order to establish improved conceptual models of sediment transport dynamics and channel morphological response following dam removal, and to inform *form-habitat* linkages related to the quantification of the short- and longer-term spatial habitat responses following dam removal. Primary objectives include:

- Assessment of sediment dynamics and associated channel morphological responses in a rough, steep-gradient channel;
- Validation of existing fractional sediment routing models, and comparison to similar, simpler models;
- Provision of information to evaluate the performance of dam removals relative to habitat improvements in the Battle Creek basin;
- Assessment of the need for Adaptive Management responses to changing physical conditions and;
- Additions to our general understanding of sediment dynamics following dam removal.

The monitoring plan proposed for Battle Creek is designed to be appropriate to the creek's morphodynamic setting (i.e., coarse sediment, largely confined morphology, channel slopes from 0.010 to 0.025, and intermittent bedrock and large boulder controls) and can be resolved into four geomorphic components, namely: 1) channel planform and surface mapping, 2) bed sediment volume and particle size surveys, 3) channel elevation surveys, and 4) sediment transport and model effectiveness evaluation. The monitoring tasks related to these components have been developed to apply to reaches adjacent to the three primary dam removals (South Diversion – 970 m; Coleman Diversion – 1290 m; Wildcat Diversion – 970 m) and encompass a three-year period in the first instance, encompassing one year of pre-removal monitoring and two years of post-removal monitoring. The plan is described in full in Section X.

III.C.2. Riparian

A complete description of this study can be found in Section VIII.

This report identifies a draft monitoring program to document potential benefits to riparian habitats hypothesized to result from increases in streamflow, a primary aspect of the Battle Creek Salmon and Steelhead Restoration Project. The AMTT's hypothesis is that pre-project summer baseflows (~5 cfs) are a limiting factor (Auble et al. 1994, Stromberg and Patten 1991) to the spatial extent, diversity (species and age class structure), and vigor of riparian forest/scrub habitats. Baseflow is likely to be a limiting factor in the less geomorphically constrained and more alluvial reaches along Battle Creek. We hypothesize that an increase in summer baseflows will benefit these habitats and that changes will be detectable through 1) repeat aerial photography mapping, 2) Field based habitat monitoring, and 3) Growth increment coring analysis.

III.C.3. Juvenile Habitat Use

A complete description of this study can be found in Section VIII.

Many uncertainties were identified related to juvenile salmonid habitat use, distribution and abundance, some of which may be key to the success of the Restoration Project. Testing some of these uncertainties may result in improvements in Restoration Project flows as well as aid in design of similar projects in other watersheds. The study will have three objectives:

1) to verify the juvenile salmonid microhabitat suitability indices upon which the Restoration Project flows are based;

2) to determine the distribution of juvenile salmonids in the Restoration Project Area to verify successful passage and production; and

3) to determine the relative abundance of juvenile salmonids in reaches of the Restoration Project to determine if they are using the reaches as predicted in conceptual and flow models.

One year of funding will be sought for the first year after the Restoration Project is completed and adult fish have been allowed access to the project area. Juvenile salmonid densities may be too low to achieve study objectives and may remain so for many years. Conducting the juvenile studies in the first year will aid in determining the feasibility and logistics of the study, as well as provide baseline data to track the projects' progress over time. During the pilot year, statistical analysis may be able to predict the juvenile population size and number of observations required to detect significant differences. Determining the statistical power of the study may aid in determining when there will be sufficient numbers of fish to begin the rest of the juvenile study. This trigger will be used to determine when to pursue funding for the rest of the study.

Juvenile habitat suitability criteria will be developed when there are sufficient numbers of juvenile salmonids. These Battle Creek specific criteria will be compared to those used in developing the Restoration Project. If considerable differences in criteria exist, model results using both criteria would be compared. Criteria will be developed using state-of-the-art techniques which take into consideration habitat availability, appropriate precision in measurement, and consideration of adjacent velocity. Spawning habitat suitability criteria are currently being developed for Spring Chinook and steelhead in Battle Creek.

The Restoration Project Area will be habitat typed, and divided into reaches. Sites approximately 100 m in length, with all major meso-habitat types, will be selected within each reach. Juvenile abundance will be determined at the sites by direct counts, by species and by size class. Relative abundance and distribution in the watershed will be compared to conceptual models of fish distribution, actual spawner distribution, water temperature and geographic features such as springs, and fish passage barriers.

Cost: $100,000 in year three of Restoration Project for pilot study.

$200,000 per year for 2 years sometime later when juvenile salmonid numbers are sufficient.

III.C.4. Cold-water Refuges

A complete description of this study can be found in Section IX.

This Focused Study will attempt to quantify the contribution of the release of cold spring water to Battle Creek to increases in production of adult and juvenile salmonids. The release of cold spring water to Battle Creek is a prominent component of the Battle Creek Salmon and Steelhead Restoration Project. However, key uncertainties exist regarding the biological benefits of this project element. Also, the potential transferability of this approach to other watershed restoration projects is not well documented.

This study will have physical and biological components. The physical extent and distribution of cold-water refuges[46] will be compared between pre-project and post-project conditions to quantify the relative contribution of this Restoration Project element. Pre-project conditions include some natural spring releases and groundwater interaction with a stream network characterized by relatively low instream flows. These natural spring releases and groundwater interaction are hypothesized to behave as thermal point sources. The post-project

[46] Cold-water refuges, in general, are areas colder than a specified temperature (e.g. some thermal criteria suitable for salmonid survival and growth) within stream reaches characterized by ambient water temperatures greater than a specified temperature. The specification of these upper and lower temperatures will be determined from examination of Contemporary literature and will be measured empirically in the physical mapping component of this study.

conditions will have the same natural inflows of cold water, plus the Restoration Project cold spring water releases, all within the context of relatively higher instream flows. The first physical component of the study will map, quantify, and compare changes in extent and distribution between these two conditions using aerial thermal imaging surveys. The physical mapping of cold-water refuges can be completed at the same time as aerial surveys of riparian habitat (see Riparian Vegetation Focused Study, Section VII) for little additional cost. The second physical component of this study will include the deployment of a network of automated temperature recording devices (in addition to those deployed for Habitat Objective 2) to record micro-scale water temperature effects within the three specific areas affected by Restoration Project cold-water releases. These thermisters will also facilitate the calibration of thermal imaging surveys.

The biological component of this study will examine the biological importance of cold-water refuges identified during the post-project physical mapping component. The utilization of cold-water refuges by juvenile and adult salmonids will be characterized and compared to habitat utilization of areas that are not influenced by cold-water refuges. The biological component of this study would necessarily occur at some future time when populations of juvenile and adult anadromous salmonids are at sufficiently high levels at which statistically meaningful responses could be measured (see similar concept in the Juvenile Habitat Use Study, Section VIII). The design of this biological study will begin with a review of the Contemporary cold-water refuge literature and a review of the pre- and post-project physical mapping. It may be prudent to link the biological component of this study with Juvenile Habitat Use Study (Section VIII) if feasible.

III.C.5. Life History

A complete description of this study can be found in Section X.

III.C.6. Fish Community Structure Evaluation

A complete description of this study can be found in Section XI.

The proposed Focused Study will estimate changes in the distribution of fish species in anadromous reaches of Battle Creek and estimate the feasibility of making abundance estimates for a few species. Cost estimates are provided for a year of baseline data from pre-project conditions and a year of sampling 3 to 5 years after the Restoration Project is complete.

Table 25. Annual monitoring and Focused Studies as organized by objective. All future cost estimates presented in this table are provisional; the scope of future monitoring studies may change as a result of Adaptive Management decisions, advances in analytical procedures, or other unforeseen developments.[47]

Line No.	Adaptive Management Monitoring Tasks	Task Type	Objectives	Responsibility	Timeline	Estimated Annual Cost (in 2004 dollars)	Funding Source[47]	Funding Priority Tier (see Section III.D.8.d)
1	Estimate adult and jack population sizes using the CNFH barrier weir.	field study	POP-1, POP-2, POP-3[48], POP-4	Resource Agencies	13 – 16 years minimum	$115,000	CBDA 1; CBDA; CVPIA;	I
1a	Compare 3 year-running average CRR with expected CRR when populations allow	analysis	POP-2, POP-3, POP-4	Resource Agencies	13 – 16 years minimum	included in Line 1	see Line 1	see Line 1
1b	Evaluate CRR trends in light of limiting factors in the Sacramento River system	analysis	POP-2, POP-3	Resource Agencies	13 – 16 years minimum	included in Line 1	see Line 1	see Line 1
1c	Compare CRR to Reference Watersheds	analysis	POP-2, POP-3	Resource Agencies	13 – 16 years minimum	included in Line 1	see Line 1	see Line 1
1d	Compare CRR 10-year trend to CRR value of 1.0	analysis	POP-4	Resource Agencies	Term of AMP	included in Line 1	see Line 1	see Line 1
2	Count adult and jack anadromous salmonids using video or electronic methods at ladders	field study	PASS-1 POP-1, POP-2, POP-3, POP-4	Licensee[49]	3 years or longer per AMP protocols	proprietary information	Licensee	II
3	Count adult and jack anadromous salmonid sub-population sizes and distribution by reach using counting facilities at new fish ladders, after ladder effectiveness is verified.	field study	POP-1 POP-2, POP-3, POP-4	Resource Agencies[49].	After Licensee's responsibility ends until no longer needed	$20,000 beginning in about 2010	CBDA 1; CBDA; CVPIA; other Resource Agency funding	II

[47] See Section III.B for definition of terms used in this table.
[48] POP-3 (restoration of fall-run and late fall-run) may be delayed until Viable Population Levels have been met for higher priority salmonids per Section I.E.
[49] Pursuant to the MOU as explained in Passage Objective 1 and the Facilities Monitoring Plan, the Licensee is expected to operate video or electronic counting equipment to count adult and jack anadromous salmonids for the first three years, or longer per AMP protocols, after the transfer of facilities from USBR to PG&E. The Resource Agencies will take over these fish counting responsibilities to satisfy Population Objective 1 at the end of the Licensee's obligation.

Line No.	Adaptive Management Monitoring Tasks	Task Type	Objectives	Responsibility	Timeline	Estimated Annual Cost (in 2004 dollars)	Funding Source[47]	Funding Priority Tier (see Section III.D.8.d)
4	Estimate juvenile production upstream of the CNFH when adult populations are large enough to produce detectable numbers of outmigrants	field study	POP-1, POP-2, POP-3, POP-4	Resource Agencies	Term of AMP	$147,000 over three years	CBDA 1; CBDA; CVPIA; other Resource Agency funding	I
4a	Compare juvenile production to expected production from previous spawners and ecological factors	analysis	POP-1	Resource Agencies	Term of AMP	included in Line 4	see Line 4	see Line 4
5	Estimate juvenile production at the terminus of each fork when adult populations are large enough to produce detectable numbers of outmigrants	field study	POP-1	Resource Agencies	2008 – 2012	$125,000	CBDA; CVPIA	I
6	Radiotelemetry study of adult steelhead and spring Chinook salmon migration upstream of the CNFH barrier weir (including an assessment of best method for determining steelhead spawning distributions)	field study	PASS-1	Resource Agencies	2006 – 2013	$211,000	CBDA 1, CBDA, other Resource Agency Funding	I
6a	Study fish passage at ladders with tagged test fish	Diagnostic field study	PASS-1	Resource Agencies	2006 – 2008	included in line 6	see Line 6	see Line 6
6b	Monitor fallback with tagged test fish	Diagnostic field study	PASS-1	Resource Agencies	2006 – 2008	included in line 6	see Line 6	see Line 6
7	Estimate adult and jack distribution using carcass counts, snorkel surveys, and /or redd surveys	field study	POP-1, POP-2, POP-3, POP-4, PASS-1, PASS-3	Resource Agencies	Term of AMP	$250,000	CBDA 1; CBDA; CVPIA; other Resource Agency funding	I
7a	Note qualitative changes in physical and biological habitat conditions for each reach during the course of all other monitoring activities	field study	POP-1	Resource Agencies	Term of AMP	included in Line 7	see Line 7	see Line 7
7b	Observe and record habitat use, and compare observed habitat use to expected habitat use	field study	HAB-1	Resource Agencies	Term of AMP	included in Line 7	see Line 7	see Line 7

Line No.	Adaptive Management Monitoring Tasks	Task Type	Objectives	Responsibility	Timeline	Estimated Annual Cost (in 2004 dollars)	Funding Source[47]	Funding Priority Tier (see Section III.D.8.d)
7c	Observe salmon or steelhead response to tailrace leaks or discharge of water	field study	HAB-3	Resource Agencies and Licensee[50]	Term of AMP	included in Line 7	see Line 7	see Line 7
7d	Monitor Ramping Rates and threshold flow levels for effects on stranding or isolating	field study	HAB-4	Resource Agencies and Licensee[50]	During scheduled outages 2002-2007	included in Line 7	see Line 7	see Line 7
7e	Monitor fish stranding during the course of other studies (e.g. stream surveys, snorkel surveys, radiotelemetry)	field study	HAB-4	Resource Agencies and Licensee[50]	Term of AMP	included in Line 7	see Line 7	see Line 7
7f	Inspect potential natural barriers during annual surveys	field study	PASS-3	Resource Agencies	Term of AMP	included in Line 7	see Line 7	see Line 7
7g	Compare spawner distribution relative to suspected barriers	analysis	PASS-3	Resource Agencies	Term of AMP	included in Line 7	see Line 7	see Line 7
7h	Compare ladder counts with spawning distribution and predicted habitat use.	analysis	PASS-1, POP-1	Resource Agencies	Term of AMP	Included in Line 7	see Line 7	see Line 7
7I	Compare observed spawner distribution relative to expected spawner distribution for a particular species	analysis	PASS-3	Resource Agencies	Term of AMP	included in Line 7	see Line 7	see Line 7
7j	Note fish injury caused by fish ladders and traps in the course of other studies (e.g. radiotelemetry, snorkel surveys)	field study	PASS-1	Resource Agencies	Term of AMP	included in Line 7	see Line 7	see Line 7
7k	Observe adult congregations below dam and compare to ladder counts	field study	PASS-1	Resource Agencies and Licensee[50]	Term of AMP	included in Line 7	see Line 7	see Line 7

[50] Licensee responsibility would be limited to reporting by staff of observations made during the course of normal project operations.

Line No.	Adaptive Management Monitoring Tasks	Task Type	Objectives	Responsibility	Timeline	Estimated Annual Cost (in 2004 dollars)	Funding Source[47]	Funding Priority Tier (see Section III.D.8.d)
7l	During the course of other field studies (e.g. including carcass count, redd surveys, snorkel surveys), assess stranding and isolation during ramping.	field study	HAB-4	Resource Agencies	Term of AMP	Included in line 7	see Line 7	see Line 7
8	Diagnose threshold flow on the North Fork at which Ramping Rates differ from 0.1 foot/hour	field study	HAB-4	Resource Agencies	During scheduled outages 2004-2005	$10,000	CBDA; CVPIA; other Resource Agency funding	II
9	Flow monitoring below each dam	field study	HAB-1	Licensee	Term of AMP	Proprietary Information	Licensee	I
9a	Monitor timing and estimated amounts of water released from canal gates and spill channels during known releases from the conveyance system	field study	HAB-3	Licensee	Term of AMP	Proprietary Information	Licensee	II
9b	Compare releases from canal gates and spill channels to stream flow rates	analysis	HAB-3	Licensee	Term of AMP	Proprietary Information	Licensee	II
9c	Monitor Ramping Rates during project-related flow adjustments	field study	HAB-4	Licensee	Term of AMP	Proprietary Information	Licensee	I
10	Monitor streamflows in both forks of Battle Creek near their mouths to assess flow patterns (includes high-flow calibration on both forks)	field study	HAB-4	CDWR	Term of AMP	$40,000	CBDA; other Resource Agency funding	II
11	Monitor longitudinal water temperature regime at a network of locations	field study	HAB-2, POP-1	Resource Agencies	5 years minimum	$17,000	CBDA 1; CBDA; CVPIA; other Resource Agency funding	I
11a	Monitor cold water from Bluff Springs	field study	HAB-2	CDFG	Term of AMP	Included in Line 11	see Line 11	see Line 11
11b	Monitor water temperature at target points within stream	field study	HAB-2,	Resource Agencies	Term of AMP	Included in Line 11	see Line 11	see Line 11

Line No.	Adaptive Management Monitoring Tasks	Task Type	Objectives	Responsibility	Timeline	Estimated Annual Cost (in 2004 dollars)	Funding Source[47]	Funding Priority Tier (see Section III.D.8.d)
12	Monitor climatic conditions	field study	HAB-2	Resource Agencies and Licensee[51]	5 years minimum	$13,000 first year and $3,000 thereafter	CBDA 1; CBDA; CVPIA; other Resource Agency funding	I
13	Water temperature modeling, including development of a rule-based plan for short-term flow releases for temperature control, if indicated	analysis	HAB-2	Resource Agencies	5 years	$16,000	CBDA 1, CBDA; CVPIA; other Resource Agency funding	II
14	Monitor timing and estimated amounts of water release from canal gates and spill channels during known releases from the conveyance system.	field study	HAB-3	Licensee	Term of AMP	proprietary information	Licensee	II
15	Compare releases from canal gates and spill channels to stream flow rates	analysis	HAB-3	Licensee	Term of AMP	proprietary information	Licensee	II
16	Monitor hydraulic parameters at fish ladders for Fail-Safe capabilities	field study	PASS-1	Licensee	Term of AMP	proprietary information	Licensee	I
17	Measure and compare hydraulic parameters at fish screens for calculated and measured diversion rates	field study	PASS-2	Licensee	Measure as relevant throughout the OMP[52]	proprietary information	Licensee	II
18	Monitor key hydraulic parameters at fish screens for Fail-Safe capabilities	field study	PASS-2	Licensee	Continuously throughout license	proprietary information	Licensee	I
19	Observe canals for entrainment during other activities and when dewatered	field study	PASS-2	Licensee	Term of AMP	proprietary information	Licensee	II

[51] Licensee responsibility will be limited to granting permission for installation of climatic monitoring equipment at Licensee facilities.
[52] Initial measurement and calibration of fish screen hydraulics will be conducted by USBR with CBDA funding as part of start-up and acceptance testing.

Line No.	Adaptive Management Monitoring Tasks	Task Type	Objectives	Responsibility	Timeline	Estimated Annual Cost (in 2004 dollars)	Funding Source[47]	Funding Priority Tier (see Section III.D.8.d)
20	Juvenile Salmonid Habitat Use Study – this Focused Study will test uncertainties related to juvenile salmonid habitat use, distribution, and abundance	Focused Study	HAB-1; population objectives	Resource Agencies	pilot study will occur in first year after implementation of Restoration Project; out years to be determined	$100,000 in pilot year; $200,000 per year in out years	CBDA 1; CBDA; CVPIA; other Resource Agency funding	II
21	Fish community structure will be studied to determine changes in distribution of fish within Battle Creek from before and after implementation of the Restoration Project.	Focused Study	none	Resource Agencies	a single year (2006) of study before and at least one year (2011) of study after implementation of Restoration Project	$152,350 in 2006 and $216,875 in 2011	CBDA 1: CBDA; CVPIA; other Resource Agency funding	III
22	Sediment Monitoring – a sediment monitoring study plan has been drafted and is in review. Final study design is pending CALFED Technical Panel comments on draft study design.	Focused Study	None	per MOU Resource Agencies	2005 - 2010	$107,352,	CBDA 1; CBDA; CVPIA; other Resource Agency funding	III
23	Riparian Studies – Three study components will be conducted as part of a baseline characterization, then again at 5 and 10 years after baseline characterization. 1) Repeat aerial photography mapping, 2) Field based habitat monitoring, and 3) Growth increment coring analysis. Goals of this Focused Study are to both evaluate benefits to riparian communities (quantity and quality) resulting from increased project baseflows, and to take advantage of the learning value of measuring riparian system response to Restoration Project actions. Documented benefits to riparian habitat could offset mitigation requirements for replacement of riparian habitat lost during construction phase.	Focused Study	None	Resource Agencies	3 years: 2005 for pre-project study, then year 5 and year 10 after Restoration Project implementation	$153,610	CBDA 1; CBDA; CVPIA; other Resource Agency funding	II

Line No.	Adaptive Management Monitoring Tasks	Task Type	Objectives	Responsibility	Timeline	Estimated Annual Cost (in 2004 dollars)	Funding Source[47]	Funding Priority Tier (see Section III.D.8.d)
24	Use Contemporary methodologies that consider flow regime to identify natural obstacles	Focused Study	PASS-3	Resource Agencies	contingent on need	contingent on need	CBDA; CVPIA; other Resource Agency funding	II
25	Apply advancements in flow/habitat relationships	Analysis	HAB-1	Resource Agencies, Licensee	contingent on need	contingent on need	CBDA; CVPIA; other Resource Agency funding	II
26	An investigation of fish utilization of nursery habitat in lower Battle Creek and possible impacts from the CNFH may be recommended. This investigation may be performed as part of an adaptive management plan that will be prepared for the CNFH.	Linkage to the CNFH-AMP	None	Resource Agencies	contingent on the CNFH-AMP	contingent on the CNFH-AMP	contingent on the CNFH-AMP	III
27	Cold-water Refuges- Studies documenting the extant, distribution and use of cold-water refuges that develops with the release of Eagle Canyon Springs, Bluff Springs, and Darrah Springs/Baldwin Creek waters to adjacent stream sections on each of the forks and mainstem.	Focused Study	None	per MOU Resource Agencies	2005 and year 10 after Restoration Project implementation	$103,000 ($61,000 if coordinated with Riparian Studies)	CBDA 1; CBDA; CVPIA; other Resource Agency funding	III
28	Life History Study – genetics study to evaluate Chinook races.	Focused Study	none	per MOU Resource Agencies	2005 – 2008	($373,081 total cost)	CBDA 1; CBDA; CVPIA; other Resource Agency funding	I
29	Conduct a Diagnostic Study in 2008 of the distribution and abundance of spawning gravels to revise 1988 estimates.	Diagnostic Study	POP-1	Resource Agencies	2008	$20,000	CBDA 1; CBDA; CVPIA; other Resource Agency funding	II

III.D.Battle Creek Adaptive Managment Process

As required by the MOU, the AMP was developed through the Consensus process by the Resource Agencies and Licensee. Interested persons were invited to attend any meeting, contribute to discussions and provide suggestions regarding development of the AMP. Specific notice, in addition to any general notice, of any such meetings was sent to (1) the Battle Creek Watershed Conservancy (BCWC); (2) CALFED; and (3) any person who requested such notification.[53]

III.D.1. Definitions

Adaptive Management means an approach that allows for changes to the Restoration Project that may be necessary in light of new scientific information regarding the biological effectiveness of the restoration measures.[54]

Adaptive Management Fund means the fund described in section III.D.4.c.

Authorized Modifications means changes to project facilities or flow operations which are determined to be necessary per Adaptive Management protocols.

Battle Creek Watershed Conservancy means an organization of landowners from the Battle Creek watershed created as a means of discussing matters of concern to local landowners, including education, watershed land and water use, solid waste management, exotic vegetation control, and fire safety, and as a means of sharing information among watershed residents about the salmon and steelhead restoration plans under development by state and federal agencies.

Battle Creek Working Group means a stakeholder and agency group comprised of nearly 20 organizations interested in restoration of salmon and steelhead to Battle Creek (see Ward and Kier 1999a for a list of member organizations).

Battle Creek Hydroelectric Project, FERC Project No. 1121 or **FERC Project No. 1121** means the hydroelectric development as described in the license issued by FERC on August 13, 1976, and as subsequently amended.

Consensus means the unanimous agreement among the Parties.[55]

Contemporary means current or modern. This word is generally used to refer to existing or future criteria that will be used to judge the success of restoration actions. When new criteria are created to replace old criteria, the use of “Contemporary” refers to the new criteria.

Diagnostic Study: A field study of limited scope and duration that is designed to provide information necessary to improve our ability to distinguish between adaptive responses as described in Contemporary Objectives Tables (Section III.A).

[53] MOU 9.1.A.1.
[54] MOU 2.1
[55] MOU 2.7

Emergency Responses are Adaptive Management responses that must be dealt with promptly (e.g., situations that create unsafe conditions or unduly threaten salmon or steelhead populations or individuals). Emergency Responses that require a change to hydroelectric project facilities or flow operations that exceed a value of $100,000, adjusted for inflation from the date of this agreement, must be approved by the AMPT; otherwise they may be approved by the AMTT. The AMPT will treat the dollar amount listed in this paragraph as a flexible guideline, and will evaluate these numbers and revise them as necessary as part of the yearly report. Any member of the AMPT may propose an adjustment to these spending guidelines for any action.

Focused Studies: Studies that are of secondary importance to accomplishing the fisheries restoration goals of the project (e.g. Sediment Monitoring) or whose implementation is contingent on need or advances in analytical methods. Focused Studies may be conducted to take advantage of learning opportunities that arise in the course of Adaptive Management.

Fail-Safe Fish Ladder means features inherent in the design of the ladder that ensure the structure will continue to operate to facilitate the safe passage of fish under the same performance criteria as designed under anticipated possible sources of failure.[56]

Fail-Safe Fish Screen means a fish screen that is designed to automatically shut off the water diversion whenever the fish screen fails to meet design or performance criteria until the fish screen is functioning again[57]

Licensee means either PG&E or any lessee or successor owner of FERC Project No. 1121.

Licensee's Commitment means a total spending cap on the part of the Licensee for expenses necessary under Adaptive Management. As more specifically identified in section II.C.4, in the event of exhaustion of the WAF and AMF, Licensee acknowledges and agrees that it will pay up to a total of $6,000,000 for all Authorized Modifications to FERC Project No. 1121 facilities or flow operations that are determined to be necessary under Adaptive Management.

Major Responses are defined as non-emergency changes to hydroelectric project facilities or flow operations that exceed a value of $25,000, adjusted for inflation from the date of this agreement. The AMPT will treat the dollar amount listed in this paragraph as a flexible guideline, and will evaluate these numbers and revise them as necessary as part of the yearly report. Any member of the AMPT may propose an adjustment to these spending guidelines for any action.

Minor Responses are defined as non-emergency changes to hydroelectric project facilities or flow operations that are less than a value of $25,000, adjusted for inflation from the date of this agreement. The AMPT will treat the dollar amount listed in this paragraph as a flexible guideline, and will evaluate these numbers and revise them as necessary as part of the yearly report. Any member of the AMPT may propose an adjustment to these spending guidelines for any action.

Parties means PG&E (or any lessee or successor), NOAA Fisheries, USFWS, and CDFG.[58]

---

[56] MOU 2.10
[57] MOU 2.11

PG&E means "the Pacific Gas and Electric Company,"[59] the utility regulated by the California Public Utility Commission that owned the Battle Creek Hydroelectric Project (FERC Project No. 1121) at the time this document was prepared. (The term "PG&E" as used in the MOU and the use of PG&E is continued in this document for the ease of the reader.) "PG&E" and "Licensee" refers to the Pacific Gas and Electric Company or any lessee or successor owner of FERC Project No. 1121.

Ramping Rates means moderating the rate of change of stream stage decrease in Battle Creek resulting from the operation of FERC Project No. 1121.[60]

Reference Watersheds means other watersheds resembling Battle Creek in geology, morphology, hydrology, and fish species diversity and distribution, which are located in close proximity to Battle Creek. Finding watersheds that are directly comparable may be problematic due to the unique nature of Battle Creek and the scarcity of current statistically valid data in nearby watersheds. For example there is no other tributary to the Sacramento River that supports populations of winter-run Chinook salmon, has constantly flowing cool springs at relatively low elevations, or currently estimates juvenile Chinook salmon production.

Resource Agencies means CDFG, NOAA Fisheries, and USFWS.[61]

Restoration Project means all measures set forth in the Agreement in Principle (MOU Attachment 1) as further developed in the MOU and having the purpose of restoring Chinook salmon and steelhead habitat associated with FERC Project No. 1121, within the Restoration Project Area.[62]

Restoration Project Area means the areas in and around the following PG&E facilities: Coleman Diversion Dam, Inskip Diversion Dam, South Diversion Dam, Wildcat Diversion Dam, Eagle Canyon Diversion Dam, North Battle Creek Feeder Diversion Dam, and Asbury Pump Diversion Dam; Battle Creek, North Fork Battle Creek and South Fork Battle Creek, up to the natural barriers at 14 miles and 19 miles above the confluence, respectively; and Eagle Canyon Springs, Soap Creek (and Bluff Springs), Baldwin Creek, and Lower Ripley Creek and each of their adjacent water bodies.[63]

Viable Salmonid Population means an independent population of any Pacific salmonid (genus *Oncorhynchus*) that has a negligible risk of extinction due to threats from demographic variation (random or directional), local environmental variation, and genetic diversity changes (random or directional) over a 100-year time frame. Other processes contributing to extinction risk (catastrophes and large-scale environmental variation) are also important considerations, but by their nature, they need to be assessed at the larger temporal and spatial scales represented by evolutionarily significant units or other entire collections of populations. [23]

---

[58] The Parties, as used in this document, differs from the MOU Parties in that it does not include USBR, whose only role in Adaptive Management is to maintain the Water Acquisition Fund account and disburse monies at the request of the AMPT through the USFWS.
[59] Part of MOU 2.14
[60] MOU 2.16
[61] MOU 2.17
[62] MOU 2.18
[63] MOU 2.19

Water Acquisition, funded by WAF, AMF, Licensee, and others, means the non-consumptive release of water from use in FERC Project No. 1121 to the natural stream channel as instream flows. Payments for additional Water Acquisition during the first ten years of the Restoration Project are made from the WAF in arrears annually to the Licensee. For additional water that will continue to be released beyond the ten-year life of the WAF, a lump-sum payment computed on the net present value of the ongoing water release will be paid at the end of the tenth year. Water acquisition does not affect the consumptive use of water downstream from the Restoration Project Area.

III.D.2. Structure

The basic organizational structure of the Adaptive Management effort consists of the Adaptive Management Policy Team[64] (AMPT) and the Adaptive Management Technical Team[65] (AMTT).

III.D.2.a. Adaptive Management Policy Team

The AMPT is a management-level cooperative group that makes all final decisions regarding the implementation of the Adaptive Management component of the Restoration Project. The AMPT has a representative from each of the Resource Agencies and Licensee. The members of the AMPT are familiar with Adaptive Management methodologies adopted by CALFED.

The AMPT provides policy direction and resolves any disputes forwarded by the AMTT through Consensus. In the event that the AMPT is unable to reach Consensus within thirty (30) days, dispute resolution procedures, described herein, shall be followed.[66]

III.D.2.b. Adaptive Management Technical Team

Voting members of the AMTT include a representative from each of the Resource Agencies and Licensee with appropriate training and experience to effectively address the technical aspects of implementing the AMP.[67] While each Party will have only one voting member, more than one individual from each Party will likely serve on the AMTT during the term of the AMP in order to effectively address the technical aspects of AMP implementation.

The AMTT has developed the AMP for approval by the AMPT and will implement the Adaptive Management component of the Restoration Project upon approval by FERC. The Chairperson of the AMTT will rotate regularly as agreed upon by the AMTT.[68]

[64] MOU 9.1.B.1
[65] MOU 9.1.B.
[66] MOU 9.1.B.1
[67] MOU 9.1.B.2
[68] MOU 9.1.B.2

III.D.3. Roles and Responsibilities

The MOU lists the roles and responsibilities for each party to the MOU pertaining to the overall Restoration Project as well as their roles and responsibilities for Adaptive Management. The following sections of this AMP list only those roles and responsibilities that pertain to Adaptive Management. See the MOU for a more complete list. The AMP provides guidance regarding roles and responsibilities only when not specifically addressed by the MOU. Any cases where the language in the AMP may conflict with the MOU represents an oversight in the AMP; in such cases, roles and responsibilities will be set by the MOU.

III.D.3.a. Licensee

A. As more fully described below, Licensee has agreed to a number of physical and operational changes and additions to FERC Project No. 1121, as well as the assumption of a number of future costs. Licensee, however, recognizes that these costs may exceed those estimates and agrees it is responsible for all cost overruns for Restoration Project components which are identified as funded by Licensee in Table 3 of MOU Attachment 1. This amount includes Licensee's participation in a portion of the biological and environmental monitoring more fully described in MOU Section 7.3. In addition to other financial obligations documented in the MOU and Facilities Monitoring Plan, Licensee's financial participation in the Adaptive Management elements of the Restoration Project will consist of absorption of the loss of foregone power as a consequence of Ramping Rate requirements described in MOU Attachment 2. In the event of exhaustion of the WAF and AMF, Licensee acknowledges and agrees that it will pay up to a total of $6,000,000 for all Authorized Modifications to FERC Project No. 1121 facilities or flow operations which are determined to be necessary under Adaptive Management. No aspect of this commitment relieves the Licensee from legal responsibilities. Nothing in the AMP is intended to bind or prejudice the Resource Agencies, or otherwise limit their respective authorities, in the performance of their responsibilities under this AMP, the MOU, and other applicable federal and state laws.[69]

B. Licensee will pay all of its internal costs associated with the FERC license amendment required to implement the Restoration Project. Licensee will also participate in and provide limited internal technical and fishery expertise, at its expense, to assist with the biological and environmental monitoring efforts described in Section 7.3 and will cooperate/work with the Resource Agencies conducting analyses, reviewing results, and identifying potential Adaptive Management actions for the Restoration Project.[70]

C. Licensee will provide the prescribed instream flow releases and Ramping Rates identified in MOU Attachments 1 and 2, and any agreed-upon future changes to these prescribed instream flow releases or Ramping Rates resulting from the AMP until the end of the current FERC license and any subsequent annual licenses. The Parties acknowledge that this commitment to provide the prescribed instream flow releases

[69] MOU 6.1A
[70] MOU 6.1.B

and Ramping Rates is subject to change by FERC in the license amendment process and at the expiration of the current license term in 2026.[71]

D. Licensee's water diversion rights associated with all dams to be decommissioned in the Restoration Project Area pursuant to the MOU shall be transferred to CDFG. CDFG agrees that the water rights transferred by Licensee to CDFG shall not be used by CDFG or any successor in interest, assignee, or designee to increase prescribed instream flow releases above the amounts developed pursuant to the AMP, nor shall they be used adversely against remaining FERC Project No. 1121 upstream or downstream diversions, until such time as the FERC license is abandoned, whereupon the limitation regarding transferred water rights will no longer apply. Licensee agrees that its riparian rights associated with lands within the Restoration Project Area shall not be used by Licensee or any successor in interest, assignee, or designee to decrease prescribed instream flow releases below the amounts developed pursuant to the AMP. Licensee agrees that any deed transferring such riparian land or rights shall contain the above restriction in use of the riparian rights.[72]

E. Licensee is responsible for the operation, maintenance, and replacement of all physical modifications to its facilities under this MOU on Battle Creek due to normal wear and tear, catastrophic damage, and any other type of damage, and will ensure that the new fish screen and ladder facilities meet the Fail-Safe criteria. Installation costs of facilities installed under the AMF protocols are excepted. Licensee's responsibilities under this section begin once the facility start-up and acceptance testing is successfully completed by USBR and Licensee. At that point Licensee shall accept and take over the facilities.[73]

F. Licensee shall be responsible for all monitoring required by FERC through the FERC license amendment for FERC Project No. 1121. Licensee will also participate in and provide limited internal technical and fishery expertise, at its expense, to assist with the biological and environmental monitoring efforts described in MOU Section 7.3, which are the responsibility of the Resource Agencies. Licensee shall be responsible for all of the facility monitoring more particularly described in the Facilities Monitoring Plan.[74]

G. Licensee shall provide at least one representative to the AMPT and one representative to the AMTT. Licensee's representatives to these two teams shall be responsible, for one year out of every four as outlined in the Protocols section, for the chairmanship of these teams on a rotating basis with the other Parties. These chairmanships includes the responsibility of publishing the annual Adaptive Management report.

H. Licensee will be responsible for assuming its costs for any FERC dispute resolution proceedings.[75]

I. As described more fully below in descriptions of individual Adaptive Management objectives, Licensee shall conduct or fund facilities monitoring consistent with the

[71] MOU 6.1.D
[72] MOU 6.1.E
[73] MOU 6.1.G
[74] MOU 6.1.M
[75] MOU 14.0

Facilities Monitoring Plan, including recording the timing and estimated amounts of water intentionally released from the canal gates and spill channels; conduct or fund the facilities monitoring, and operation and maintenance of hydroelectric project facilities; conduct or fund adult counts at fish ladders in the initial three-year period of operation; repair or replace fish counting equipment in fish ladders in the initial three-year period of operation. Pursuant to Adaptive Management protocols, if salmon and steelhead populations are insufficient to affirm ladder effectiveness under continuous duty, then Licensee may conduct or fund adult counts at fish ladders for a longer period of time as agreed upon by the Parties. All data collected as part of Adaptive Management monitoring will conform to data management protocols in section III.D.7.

III.D.3.b. NOAA Fisheries

A. In the next relicensing proceeding for FERC Project No. 1121, to the extent NOAA Fisheries determines that these provisions are consistent with the biological opinion rendered for the proposed Restoration Project and its responsibilities under the ESA to conserve threatened and endangered species and their habitats,[76] NOAA Fisheries agrees to support the continuation of the prescribed instream flow releases described in MOU Attachment 1 and Ramping Rates resulting from Adaptive Management.[77]

B. NOAA Fisheries agrees to support, to the extent NOAA Fisheries determines that these provisions are consistent with the biological opinion rendered for the proposed Restoration Project and its responsibilities under the ESA to conserve threatened and endangered species and their habitats, any changes to instream flow releases or Ramping Rates resulting from Adaptive Management, subject to applicable law, and to support incorporating Battle Creek monitoring needs into appropriate CVPIA, CALFED, and other monitoring programs.[78]

C. NOAA Fisheries shall provide at least one representative to the AMPT and one representative to the AMTT. NOAA Fisheries' representatives to these two teams shall be responsible, for one year out of every four as outlined in the Protocols section, for the chairmanship of these teams on a rotating basis with the other Parties. These chairmanships includes the responsibility of publishing the annual Adaptive Management report.

D. NOAA Fisheries will be responsible for assuming its costs for any FERC dispute resolution proceedings.[79]

E. As described more fully below in descriptions of individual Adaptive Management objectives, NOAA Fisheries, in cooperation with USFWS and CDFG, may conduct or fund or seek funding from sources other than the Licensee for any necessary unfunded element of Adaptive Management. All data collected as part of Adaptive Management monitoring will conform to data management protocols in section III.D.7.

[76] MOU 6.3.B
[77] MOU 6.3.B.3
[78] MOU 6.3.C
[79] MOU 14.0

F. NOAA Fisheries will define recovery goals for anadromous salmonid species in Battle Creek listed under the ESA. These include species currently listed (i.e., winter-run Chinook salmon, spring-run Chinook salmon, and steelhead) as well as any other anadromous fish species that may be listed under the ESA at any time during the term of the AMP.

III.D.3.c. USFWS

A. In the next relicensing proceeding for FERC Project No. 1121, USFWS agrees to support the continuation of the prescribed instream flow releases described in MOU Attachment 1 and Ramping Rates resulting from Adaptive Management.[80]

B. USFWS agrees to support any changes to instream flow releases or Ramping Rates resulting from Adaptive Management, subject to applicable law, and to support incorporating Battle Creek monitoring needs into appropriate CVPIA, CALFED, and other monitoring programs.[81]

C. USFWS shall provide at least one representative to the AMPT and one representative to the AMTT. USFWS's representatives to these two teams shall be responsible, for one year out of every four as outlined in the Protocols section, for the chairmanship of these teams on a rotating basis with the other Parties. These chairmanships includes the responsibility of publishing the annual Adaptive Management report.

D. USFWS will be responsible for assuming its costs for any FERC dispute resolution proceedings.[82]

E. As described more fully below in descriptions of individual Adaptive Management objectives, USFWS, in cooperation with CDFG and NOAA Fisheries, shall conduct or fund or seek funding from sources other than the Licensee for monitoring and data assessments including those associated with all fish population objectives; data collection and report preparation associated with Habitat Objective 1; water temperature and climatic data collection associated with Habitat Objective 2; relevant biological monitoring and measurement of any known release or discharge from the hydropower water conveyance system that elicits a response from salmon or steelhead associated with Habitat Objective 3; incidental monitoring and the Diagnostic Ramping Rate assessment associated with Habitat Objective 4; biological monitoring using ladder counts after the ladder is deemed effective associated with Passage Objective 1; the repair or replacement of fish counting equipment in fish ladders after the initial three-year period of operation; and monitoring activities associated with Passage Objective 3. All data collected as part of Adaptive Management monitoring will conform to data management protocols in section III.D.7.

[80] MOU 6.4.B.3
[81] MOU 6.4.C
[82] MOU 14.0

III.D.3.d. CDFG

A. In the next relicensing proceeding for FERC Project No. 1121, CDFG agrees to support the continuation of the prescribed instream flow releases described in MOU Attachment 1 and Ramping Rates resulting from Adaptive Management.[83]

B. CDFG agrees to support any changes to instream flow releases or Ramping Rates resulting from Adaptive Management, subject to applicable law, and to support incorporating Battle Creek monitoring needs into appropriate CVPIA, CALFED, and other monitoring programs.[84]

C. CDFG shall provide at least one representative to the AMPT and one representative to the AMTT. CDFG's representatives to these two teams shall be responsible, for one year out of every four as outlined in the Protocols section, for the chairmanship of these teams on a rotating basis with the other Parties. These chairmanships includes the responsibility of publishing the annual Adaptive Management report.

D. CDFG will be responsible for assuming its costs for any FERC dispute resolution proceedings.[85]

E. As described more fully below in descriptions of individual Adaptive Management objectives, CDFG, in cooperation with USFWS and NOAA Fisheries, shall conduct or fund or seek funding from sources other than the Licensee for monitoring and data assessments including those associated with all fish population objectives; data collection and report preparation associated with Habitat Objective 1; water temperature and climatic data collection associated with Habitat Objective 2; relevant biological monitoring and measurement of any known release or discharge from the hydropower water conveyance system that elicits a response from salmon or steelhead associated with Habitat Objective 3; incidental monitoring and the Diagnostic Ramping Rate assessment associated with Habitat Objective 4; biological monitoring using ladder counts after the ladder is deemed effective associated with Passage Objective 1; the repair or replacement of fish counting equipment in fish ladders after the initial three-year period of operation; monitoring activities associated with Passage Objective 3; modification of natural fish passage barriers. All data collected as part of adaptive Management Monitoring will conform to data management protocols in section III.D.7.

III.D.4. Funding

Funding for provisions of this AMP will come from several sources including a WAF and AMF, both initially described in the MOU, cost sharing by the Parties, and solicitations from other funding sources. No provisions in the MOU or the following sections on funding are intended to limit the ability of the Parties, or third party donors, from augmenting the Adaptive Management budget to continue to implement actions supported by AMP protocols.

[83] MOU 6.5.C.3
[84] MOU 6.5.D
[85] MOU 14.0

III.D.4.a. CALFED Monitoring Fund

As part of the original grant for the Restoration Project, CALFED included $1,000,000 for monitoring activities. This money will be used to fund monitoring needs that are not funded by other sources.

Funding for the first three years of monitoring activities and Focused Studies will be requested from CBDA as part of the final Restoration Project funding request (. At the first formal meeting of the AMPT, the AMPT will determine the steps to take to complete additional study proposals, to prioritize funding needs for monitoring activities, and will decide how to proceed on seeking necessary funds.

Table 25. Monitoring Budget Summary

Funding Source	Funding Options*	Estimated Amount (in 2004 $; for known tasks in Table 23)	Duration of Funding
CBDA 2004 Grant Cycle	Tiers I, II, III	$3,359,969	2005-2007
CBDA 2004 Grant Cycle	Tiers I, II only	$2,866,561	2005-2007
CBDA 2004 Grant Cycle	Tier I only	$2,424,871	2005-2007
CBDA 2007 Grant Cycle	Tiers I, II, III	$3,930,310	2008-2010
CBDA 2007 Grant Cycle	Tiers I, II only	$3,503,864	2008-2010
CBDA 2007 Grant Cycle	Tier I only	$2,898,811	2008-2010
CBDA 2010 Grant Cycle or other Agency funding	Tiers I, II, III	$10,036,485	2011-2026

* Complete adaptive management monitoring would include studies from all three funding priority tiers (i.e. I, II, and III). In the case that available funds are insufficient to fund the complete monitoring budget, studies from lower funding priority tiers (e.g. level III then level II) are successively dropped to reduce costs as shown here. See Section III.D.8.d Monitoring Funding Contingencies for a description of funding priority tiers.

III.D.4.b. Water Acquisition Fund

An important component of the Restoration Project will be a Water Acquisition Fund (WAF). The purpose of the WAF is to establish a ready source of money which may be needed for future purchases of additional instream flow releases in Battle Creek which may be recommended under the AMP during the ten (10) year period following the initiation of prescribed instream flow releases listed in MOU Attachment 1. The WAF shall be used solely for purposes of purchasing additional environmentally beneficial instream flow releases pursuant to the protocols developed by the Resource Agencies and Licensee. The Parties acknowledge that if additional instream flow releases are determined by the Resource Agencies to be required pursuant to the protocols described in MOU Section 9.2 A 3, the ESA, or other applicable law, and (1) the ten (10) year period described above has elapsed or (2) there are not sufficient funds in the WAF or the AMF to pay for such additional instream flow releases, then Licensee shall be responsible for the cost of such instream flow releases up to the maximum commitment of $6 million for changes in operation and modifications to facilities.[86]

The WAF account will be funded with federal funds described in Section 10.2 and administered by the Resource Agencies following consultation with appropriate interested parties. USBR shall commit $3,000,000 of such funds to an account or subaccount for the WAF within four months of CALFED approval of federal funds described in MOU Section 10.2. Account disbursement instructions will be developed jointly by the Resource Agencies and Licensee. USFWS shall request disbursements from the WAF in writing, based on the account disbursement instructions.[87]

Protocols to identify environmentally beneficial flow changes for anadromous salmonids under the AMP, to be funded from the WAF, are detailed in a subsequent section of this plan.

During the ten-year effective period of the WAF, payment to Licensee for consensually agreed to or FERC-approved increased flow releases, and interim instream flow releases which have been taken pending FERC action, will be made in arrears annually. After January 1 following the expiration of the WAF, all uncommitted funds will revert to CALFED, or as otherwise provided by law. During the last year of the WAF, and to the extent that adequate moneys remain in the WAF, funds for agreed to prescribed instream flow releases which will be delivered after expiration of the WAF will be paid to Licensee in one lump-sum based on the net present value of foregone energy for the period inclusive of the realized increased prescribed instream flow releases and expiration date of the current FERC license.

The method of valuation of any additional environmentally beneficial prescribed instream flow releases for the purpose of compensation from the WAF shall be similar to that used for estimating the net present value of foregone power in MOU Attachment 1. The annual in arrears payments described above will be calculated by computing the additional energy foregone on a daily basis over the prior year due to increased prescribed instream flow releases multiplied by the weighted daily energy price published by the California Power Exchange for northern California, or equivalent. The lump-sum payment described above will be determined based on the average annual additional foregone energy associated with increased prescribed instream flow releases for a typical water year (e.g., water year 1989). The net present value payment will be based on the appropriate power values, escalation factor, and discount rate.[88]

Section 9.2.A.4 of the MOU provides for the calculation of a net present value payment from AMFs at the end of year 10 for continuing additional instream flows determined necessary under Adaptive Management protocols. This section, however, left undetermined the actual power values; escalation factors, and discount rate to be used in such a calculation. These variables were left undetermined because the Adaptive Management Parties recognized that the conditions under which these variables were defined during negotiations were likely to change (perhaps significantly) between the finalization of the MOU and the end of the ten-year effective period of the WAF.

[86] Based on MOU 9.2.A.1 and subsequent discussions.
[87] MOU 9.2.A.2
[88] MOU 9.2.A.4

Residential and industrial demand, available supply, and available access via transmission and distribution systems will affect future power values. The future power values used in MOU negotiations were based on projections of the California energy market by the California Energy Commission (CEC). If the CEC is still developing similar projections when the WAF is accessed for the year 10 lump-sum net present value payment, their estimates will be used. In the event that the CEC no longer exists, or they no longer develop such projections, an impartial set of projections will need to be used. The first preference is to use projections developed by another State of California agency that has responsibility for developing published projections. If no such agency exists, the Parties will agree to an appropriate substitute through Adaptive Management decision-making protocols.

The previous paragraph assumes that the hydroelectric project will be participating in a deregulated energy market. In the event that the hydroelectric project is regulated by the California Public Utilities Commission, replacement power value and discount rate appropriate to the regulated utility status would be used by the Parties in arriving at a lump-sum net present value payment.

Escalation (or inflation) factors will be agreed upon by the Parties through Adaptive Management decision-making protocols.

During negotiation of the MOU, the electric generation industry in California was transitioning from a regulated industry to a deregulated industry. At the end of the ten-year effective period of the WAF, when funds for agreed to prescribed instream flow releases will be paid to Licensee in one lump-sum, the electric generation industry may be completely deregulated. The discount rate used was based on PG&E's weighted average cost of capital. This discount rate was justified due to PG&E's regulated utility status, more specifically, the cost-of-service regulation of its hydroelectric generation assets. The Licensee may or may not have this status at the end of the ten-year effective period of the WAF. As a fully deregulated industry, the appropriate discount rate would be based on the expected return by the Licensee in the deregulated industry. It is not clear what such a discount rate will be at the end of the ten-year period.

Keeping the previous paragraph in mind, the discount rate should be applicable to the Licensee and agreed upon by the Parties through Adaptive Management decision-making protocols.

The amount of water that the WAF and AMF might purchase was estimated in 2004 for project planning purposes (Table 26) and was based on the assumption that the WAF was used to purchase flows for a year in 2013 and then to purchase the same amount of flow from 2014 through the end of the FERC license in 2026. This estimate assumed the price of decreased power production at $62.44/MWh. The exact amount of water that the WAF and AMF might purchase would need to be calculated at the time future disbursements from the WAF or AMF are requested, using the protocols described above.

Table 26. Estimate (derived in 2004) of the amount of water that could be purchased by the WAF and AMF in 2013 for years 2013 through 2026.

	Water Acquisition Fund	Water Acquisition Fund plus Adaptive Management Fund
Expenditure from WAF or WAF+AMF (Net present value cost of decreased power generation)	$2,991,874	$5,958,494
Total increased acre feet of flow in a year (af/yr)	7,972	13,920

III.D.4.c. Adaptive Management Fund

Another component of the Restoration Project will be an Adaptive Management Fund (AMF) to implement actions developed under the AMP. The Parties agree that the purpose of the AMF is to provide a readily available source of money to be used for possible future changes in the Restoration Project. The AMF shall be used only for Restoration Project purposes directly associated with FERC Project No. 1121 including compensation for prescribed instream flow release increases after the exhaustion or termination of the WAF. The AMF shall be administered pursuant to the AMP protocols. The AMF shall not be used to fund monitoring or construction cost overruns.[89]

The AMF, in the amount of $3,000,000, will be made available to Licensee and the Resource Agencies by the Packard Foundation, to fund those actions developed pursuant to the AMP. The Packard Foundation shall deposit the $3,000,000 in an interest-bearing account managed by The Nature Conservancy (TNC) pursuant to a separate agreement to be developed jointly by the Resource Agencies, Licensee, and TNC. Account disbursement instruction will be developed jointly by the Resource Agencies, the Packard Foundation and Licensee.

The Parties agree that (1) interest on the moneys in the AMF will accrue to the account and shall be applied to changes in the Restoration Project adopted pursuant to the Adaptive Management protocols; and (2) all uncommitted funds in the AMF will revert to the Packard Foundation at the end of the current term of the license for FERC Project No. 1121. USFWS shall request disbursement from the AMF in writing, based on the protocols identified below.[90]

Protocols to designate environmentally beneficial Adaptive Management actions to be funded from the AMF pursuant to the AMP, are detailed in a subsequent section of this plan.

For funding prescribed instream flow increases, the protocols will be the same as for the WAF described in MOU Section 9.2 A 3. For funding facility modification, the protocols will be the same as that described in MOU Section 9.2 A 3, with two exceptions: (1) no interim action will be implemented prior to any required FERC approval of a license amendment or other necessary action by FERC, and (2) for all actions resolved by FERC, in which Licensee is

[89] MOU 9.2.B.1
[90] MOU 9.2.B.2

in the minority opinion (opposing a proposed action expenditure), the AMF will contribute sixty percent (60%) of any resulting facility modification cost; in the case of Licensee being in the majority opinion (in support of a proposed action expenditure), the AMF will contribute one hundred percent (100%) of any resulting facility modifications.[91]

The amount of water that the WAF and AMF might purchase was estimated in 2004 for project planning purposes (Table 26). The assumptions for this estimate are described in the previous section on the WAF.

III.D.4.d. Licensee Commitment

The principles of Adaptive Management include agreed-upon measures to ensure resources are not expended on an open-ended process of change that is out of proportion with the specified goal. While this level of detail was not addressed in the MOU, in the development of this AMP measures were more specifically defined, resulting in a funding commitment on the part of the Licensee in the amount of $6 million for continuation of Adaptive Management actions after exhaustion of the WAF and AMP. In aggregate, the funding commitments will provide up to $12 million for Adaptive Management actions over the life of the Restoration Project.

In the event of exhaustion of the WAF and AMF, Licensee acknowledges and agrees that it will pay up to a total of $6,000,000 for all Authorized Modifications to FERC Project No. 1121 facilities or flow operations which are determined to be necessary under Adaptive Management.[92] No aspect of this commitment relieves the Licensee from legal responsibilities. Nothing in the AMP is intended to bind or prejudice the Resource Agencies, or otherwise limit their respective authorities, in the performance of their responsibilities under this AMP, the MOU, and other applicable federal and state laws.[93]

This commitment is intended to provide a readily available source of money to be used for possible future changes in the Restoration Project.[94] This commitment shall be used only for Restoration Project purposes directly associated with FERC Project No. 1121 including compensation for prescribed instream flow release increases after the exhaustion or termination of the WAF and after the exhaustion or termination of the AMF.[95] This commitment shall be administered pursuant to the AMP protocols and shall not be used to fund monitoring or construction cost overruns.[96] Furthermore, this commitment may fund future purchases of additional instream flow releases in Battle Creek which may be recommended under the AMP.[97]

[91] MOU 9.2.B.3
[92] Parallels MOU 6.1.A
[93] MOU 5.7
[94] Parallels MOU 9.2.A.1
[95] Parallels MOU 9.2.B.1
[96] Parallels MOU 9.2.B.1
[97] Parallels MOU 9.2.A.1

III.D.5. Term

The term of the AMP will begin when the FERC license amendment for the Restoration Project is granted, will coincide with the implementation of restoration actions, and will continue through the current FERC license. In addition, the AMP also includes more specific end points for some objectives, monitoring approaches, or responses.

III.D.5.a. Water Acquisition Fund

The WAF is available as a ready source of money for future purchases of additional instream flow releases in Battle Creek during the ten (10) year period following the initiation of prescribed instream flow releases listed in Attachment 1 of the MOU. After January 1 following the expiration of the WAF, all uncommitted funds will revert to CALFED, or as otherwise provided by law.[98]

III.D.5.b. Adaptive Management Fund

Provisions for establishment and administration of the interest-bearing AMF account became effective December 1, 2000, with the execution of an agreement between TNC and the MOU Parties. The AMF account will be established 30 days after receipt of a final FERC Order approving the FERC license amendment which reflects the provisions of the Restoration Project and Adaptive Management. To the extent it is not exhausted, this fund will remain in effect from that point through and including June 30, 2026, or any earlier date upon which the FERC License for FERC Project No. 1121 expires or is revoked, unless earlier terminated pursuant to the agreement between TNC and the MOU Parties regarding the AMF.[99]

III.D.5.c. FERC License

The license for the Battle Creek Hydroelectric Project, FERC Project No. 1121 was issued by FERC on August 13, 1976, and is scheduled to expire on July 31, 2026, unless extended by FERC.[100]

III.D.6. Adaptive Management Activities on Private Land

Extensive field investigations will be conducted by the Parties to implement the objectives of the AMP. Much of this work may be conducted on private land or access to sampling sites may require travel across private land. To respect landowner rights, all Adaptive Management activities on private land will follow these protocols.

A Shasta or Tehama County representative of either CDFG or USFWS will coordinate all Adaptive Management field activities undertaken by the Parties or their agents by serving as, or designating, a Point of Contact (POC). The activities coordinated by the POC may include, but

[98] Mimics MOU 9.2.A
[99] Per the May 7, 2000 agreement between The Nature Conservancy and the MOU Parties regarding the adaptive management fund.
[100] Mimics MOU 2.4 and MOU 15.0

are not limited to, field surveys, site visits, and construction work associated with adaptive responses. The POC will work with Field Coordinators designated by each of the Parties. The POC will serve as the primary contact person for the public, and will coordinate and be responsible for the maintenance and renegotiation of landowner agreements and right-of-way easements established by the USBR during Restoration Project initiation. A standard landowner agreement and easement form will be developed by the AMTT with the help of the BCWC that could be modified in any way to meet individual landowner needs. The POC will develop Contemporary communications tools such as a telephone "hotline" or web site to provide timely and complete information to landowners and other parties interested in Adaptive Management activities.

Field Coordinators will be responsible for coordinating all field investigations and Adaptive Management activities conducted by the members or agents of their respective agency. Field Coordinators will also assist the POC by interfacing with the public. For instance, Field Coordinators will be responsible for notifying landowners of activities on individual private lands.

A seasonal schedule of all Adaptive Management activities conducted by any of the Parties or their agents will be maintained by the POC. This schedule, and any updates, will be distributed by the POC to all Field Coordinators, affected landowners, hydroelectric project operators designated by the Licensee, appropriate CDFG and NOAA Fisheries wardens or enforcement officers, representatives of the BCWC, CALFED, and any person requesting such notification.[101] Day-to-day changes in field scheduling approved by Field Coordinators will be communicated by Field Coordinators directly to the POC, affected landowners, hydroelectric project operators designated by the Licensee, and appropriate CDFG and NOAA Fisheries wardens or enforcement officers.

The POC will accompany all field personnel at least during the initial field surveys each year. The POC's presence during subsequent surveys will be decided at the time of those later surveys.

Adaptive Management activities will only be performed within the Restoration Project Area. All field personnel must adhere to the following guidelines when performing Adaptive Management activities in Battle Creek:

1) Minimize the number of field trips into the Battle Creek watershed by combining monitoring activities and coordinating schedules with other agencies/field teams.
2) Field work activities must be conducted safely. For example, field personnel will always work in teams of two or more. In case of any emergency, contact the Licensee's designated emergency number or hydroelectric project operator.
3) Field personnel will honor and respect all landowner agreements or right-of-way easements and should carpool as much as possible to minimize disturbance to the landowners and their property.
4) All road gates will be left the way they are found (i.e., if a gate is found open, it will be left open; if a gate is found closed, it will be left closed after passing through, regardless of the duration of activities within the gated area.

[101] From MOU 9.A.1

5) Roads will not be damaged by driving on them when they are too wet or soft. Field personnel will walk when roads are wet, and will photograph and document any road damage that may occur and report the incident to the Field Coordinator. If field personnel find a road with existing soil disturbance (e.g., rutting, erosion, etc.), it will not be used and it will be documented and reported to the POC by the Field Coordinator.

6) All agency personnel going into the field must carry official photo identification (e.g., valid driver's license) and must freely offer it to any property owner or employee who requests it.

7) Field personnel will be required to sign entry logs at or near the point of entry for each site if required by property owners.

8) All field supplies brought into a site must also be removed including field equipment (except long-term monitoring equipment approved by affected landowners), personal belongings, or garbage.

9) Fire damage is a real and serious concern. Field crews will check with the Field Coordinator for the current fire hazard status before performing fieldwork. Field crews will avoid motorized vehicular access during periods of extreme fire hazard as determined by the Field Coordinator. There will be no smoking at any time on any private property. Vehicles should have a fire extinguisher and a shovel. No vehicles will be parked where grass or other vegetation might contact the underside of the vehicle. Evidence of fires possibly triggered by field personnel (e.g., burning odors, smoke) will be investigated immediately and reported if necessary.

10) Field personnel have no right to recreational or personal use of any private property. Pets are not to be taken into the field and onto private property. Only personnel authorized by Field Coordinators may accompany field crews on any private property.

11) Field personnel will record only data that meets the purpose of the visit. Incidental observations will not be recorded or shared with the public, but may be shared with the landowner upon request at any time. Field personnel will not discuss specifics of data collected from private properties with anyone outside of the staff designated by the AMP data management protocols.

III.D.7. Data Management

It will be the responsibility of any Party collecting or funding the collection of data as part of Adaptive Management monitoring to ensure that the following data management protocols are carried out. All data collected as part of Adaptive Management monitoring will be:

- Collected according to scientifically sound protocols developed by the agencies collecting or funding data collection;
- Collected following AMP protocols for data collection on private lands;
- Reported to the AMTT in a timely fashion as determined by the AMPT. Some data may need to be transmitted to the AMTT by the responsible Party frequently (e.g. in real time), other data may be reported less frequently (e.g. annually at the regularly scheduled October meeting). The AMPT will specify the data reporting requirements within the study plan of each study conducted under this AMP.
- Validated using scientifically sound quality assurance and quality control procedures before being released to the public or other agencies, or used in decision making;
- Include information consistent with CMARP, EPA, or other Contemporary standards;
- Stored or disseminated in an appropriate agency information system that is publicly accessible which provides for public distribution of information; and

- Transmitted to the BCWC for storage or dissemination in an information system operated and maintained by the BCWC and will include metadata and narrative descriptions of the goals, objectives, methods of data collection, and a description of the limitations on the use of the data.

Contemporary CMARP and EPA data collection standards encourage the collection of the following information: date; time; station code; GPS (global positioning system) coordinates; species; length; length criteria; marks or tags; life stage; plus count; live/dead; effort information; trapping efficiency; basic water quality data such as temperature, turbidity, flow; and metadata. Adaptive Management data collection and storage standards may change to meet any changes in Contemporary standards. The Adaptive Management Party responsible for collecting a particular data set will be responsible for collecting, summarizing, and disseminating data to the AMTT in a timely fashion, within a time frame that will enable to the AMTT to make decisions according to the meeting schedule described in Section III.D.8.a.

III.D.8. Process

Regular meetings of the AMTT will be scheduled four times per year to allow data collection scheduling in accordance with fish life-history requirements and funds management. In addition, at least one meeting will be held between the Restoration AMP technical Team and the CNFH Adaptive Management Team. Restoration AMP Policy team meetings may be scheduled on an as needed basis if the Technical Team needs to seek resolution on issues of mutual concern to the two Adaptive Management Programs. In addition to considerations of grant scheduling and funding, each regular meeting will address any possible Adaptive Management actions that need to be taken immediately. All regularly scheduled meetings of the AMTT will be open to the public.

At an AMTT meeting to be held in **October**, summary reports will be presented by each Party responsible for collecting data in the preceding field season. These data reports will be used to prioritize any possible Adaptive Management responses and will be the foundation for the preparation of a draft annual report. The draft annual report will be presented and discussed at a meeting to be held in **January**. The draft annual report will be presented and discussed at an annual stakeholders meeting in **February**. The final annual report will be presented and discussed at a regular meeting in **March**. At this time, the annual report will be ready for submittal to AMPT. Field study and data collection will also be coordinated at the March meeting.

All regularly scheduled meetings of the AMPT will be open to the public. The AMPT will meet regularly, at least once per year. The annual meeting will be held in **late March** and consist of two purposes. The first purpose will be primarily directed at budget review, funds management, and approval of the annual Adaptive Management report in time to meet funding agency deadlines. The second purpose will be to provide updates to stakeholders and for public presentation and comment of the annual report. This meeting will be formally announced to the public according to the specific public announcement protocols.

Ad hoc meetings of either the AMTT or AMPT may be scheduled as needed, following the specified Adaptive Management decision making protocols. Ad hoc meetings called in response to emergency conditions may be conducted in person or with the aid of telecommunications, as determined at the time of the emergency by either the AMTT or AMPT. Advance public notice requirements specified for regular meetings of the AMPT need not be implemented for ad hoc meetings of the AMPT in the case of emergencies. Ad hoc meetings of the AMPT scheduled for a specific emergency and not announced with a formal public notice, will consider only issues pertinent to the emergency at hand and will not make decisions on issues normally addressed at regular meetings. All ad hoc meetings of the AMTT and AMPT will be open to the public.

III.D.8.a. Meeting Process

Annual meetings of the AMPT and regularly scheduled AMTT meetings will be formally announced to all Parties, the BCWC, CALFED, and any person requesting such notification.[102] Chairpersons of the AMPT and AMTT will provide certified notice of regularly scheduled meetings at least one month in advance to Party representatives of their respective team and representatives of the BCWC, CALFED, and any person requesting such notification.[102] Members of each team then have one week to respond with suggestions for the meeting agenda, which will be circulated by the Chairperson to representatives of each Party and representatives of the BCWC, CALFED, and any person requesting such notification.[102]

The annual AMPT meeting, and ad hoc meetings of the AMPT that are not scheduled in direct response to an emergency, will be formally announced to the public. The scheduled meeting location and time, as well as the meeting agenda, will be published a minimum of three times, at least two weeks before scheduled meetings, in major newspapers, or other Contemporary standard media, in Shasta and Tehama Counties. Interested persons may attend any meeting, contribute to discussions, and provide suggestions regarding implementation of the AMP.[103]

At least one representative from each of the Parties will be required to attend regularly scheduled and ad-hoc meetings announced according to the aforementioned process, or to provide a proxy. A proxy may be transmitted electronically if followed by a document meeting Contemporary formal documentation standards adopted by the AMPT. To assure that absenteeism does not impede the decision making process, if a Party or Parties is not represented in-person or by-proxy at regularly scheduled and ad-hoc meetings announced according to the aforementioned process, and unless a written proxy from the absent party conforming to Contemporary formal documentation standards is received by the Chairperson of the meeting within two weeks, the dispute resolution process will be triggered.

The Chairs of the AMPT and AMTT will be held by a representative of one of the Parties. Each Chair will rotate annually among the four Parties such that no Party will be the Chair of one team more than once in any four-year period. Furthermore, the Chair for the AMTT will always represent a different Party than the Chair for the AMPT so that the Chairpersons of the AMTT and the AMPT are never representatives of the same Party at any

[102] MOU 9.A.1
[103] MOU 9.A.1

given time.[104] A Chairperson-elect will be appointed for each team to succeed the Chairperson at the expiration of the Chairperson's one-year term. This appointment must consider the Chairperson rotation protocols set forth in this paragraph.

All decisions made by the AMTT and AMPT will be made by voting representatives of each Party at regularly scheduled or ad hoc meetings according to the aforementioned notification and absentee rules. All decisions made by the AMTT must be made by Consensus or will be referred to the AMPT. All decisions made by the AMPT will conform to the following possible outcomes:

- A 4-to-0 vote (Consensus) carries the motion;
- A 3-to-1 vote triggers dispute resolution protocols;
- A 2-to-2 vote leads to further discussion.
- A 3-to-0 vote (absenteeism or abstention) triggers dispute resolution.

At the time a decision is made, the AMPT will set out a schedule for the implementation of the decision and will identify the Party(ies) responsible for implementing the decision. The responsible Party(ies) will provide timely progress reports to the AMPT according to the assigned schedule. At the time any decision is made, including adaptive responses, the AMPT or AMTT will consider the decision's effect on new or existing AMP uncertainties, conceptual models, and the possible effects of the decision on monitoring approaches.

III.D.8.b. Reporting

Data collected from studies conducted under this AMP will be reported to the AMTT in a timely fashion as determined by the AMPT (Section III.D.7).

An Adaptive Management report will be prepared each year by the AMTT and approved by the AMPT. This annual report will document monitoring and data assessment approaches and results from the previous year, will identify any possible trigger events that occurred which require an adaptive response, will propose the adaptive response to be taken, will report on results of adaptive responses taken since the most recent report, and will evaluate spending guidelines involved in categorizing major, minor, and Emergency Responses. This report may also include any results from Diagnostic or Focused Studies conducted as part of adaptive responses. Documentation of monitoring and data assessment approaches, and Diagnostic of Focused Studies, will be achieved by compiling field study reports prepared by Parties that conducted or funded individual field studies. The compilation of these field study reports, as well as preparation of report sections identifying trigger events and adaptive responses, will be done jointly under the oversight of the AMTT and AMPT Chairpersons, or their designates. The annual Adaptive Management report will be presented at the annual meeting of the AMPT, to the BCWC, BCWG, and other stakeholders.

[104] Sense of MOU 9.B.1 and 2

III.D.8.c. Adaptive Response Process

After a trigger event has occurred, one of three types of adaptive responses will follow. They are Major, Minor, or Emergency Responses. Major Responses are defined as non-emergency changes to hydroelectric project facilities or flow operations that exceed a value of $25,000, adjusted for inflation from the date of this agreement. Minor Responses are defined as non-emergency changes to hydroelectric project facilities or flow operations that are less than a value of $25,000, adjusted for inflation from the date of this agreement. Emergency Responses are Adaptive Management responses that must be dealt with promptly (e.g., situations that create unsafe conditions or unduly threaten salmon or steelhead populations or individuals). Emergency Responses that require a change to hydroelectric project facilities or flow operations that exceed a value of $100,000, adjusted for inflation from the date of this agreement, must be approved by the AMPT; otherwise they may be approved by the AMTT. The AMPT will treat the dollar amounts listed in this paragraph as flexible guidelines, and will evaluate these numbers and revise them as necessary as part of the yearly report. Any member of the AMPT may propose an adjustment to these spending guidelines for any action. Adaptive Management responses from any of these three categories may be required to conform to decision-making processes such as federal Power Act, NEPA, CEQA, or Clean Water Act protocols and any other appropriate state or federal law.

Major Responses will be proposed in the annual report and will be proposed for funding according to response prioritization protocols described below. Responses that would be appropriately funded by the WAF or AMF would be approved at a regular AMPT meeting and the USFWS would then request disbursement of the money from USBR according to USBR protocols. Responses that would be funded by other agencies will be described in a proposal formatted per Contemporary guidelines of the targeted funding agency and will include, as a minimum, justification and alternatives, expected benefit, and the priority of species to be affected by the proposal. These response proposals would be submitted after their approval by the AMPT in late March, at the earliest opportunity for funding by target funding agencies.

Minor Responses will be considered and may be approved at the next regularly scheduled or ad hoc meeting of the AMTT or AMPT. Emergency Responses may be considered and approved at ad hoc meetings of the AMTT or AMPT, depending on the magnitude of the change required, as specified above.

III.D.8.d. Contingencies

Non-Restoration Project Emergencies

Emergencies in the Battle Creek watershed that could affect the restoration of salmon and steelhead, but that are not directly caused by the Restoration Project (e.g., hazardous spills or toxic leaks), would be addressed by standard, official channels. The AMTT would be available to consult with the interested parties as to the possible impacts these types of emergencies may have on the fish or habitat in the Restoration Project.

Unforeseen Natural and Human-Caused Disturbances

One can imagine any number of unforeseeable disturbances that could affect stream habitat, fish populations, or hydroelectric project facilities during the course of this AMP that could confound Adaptive Management of the Restoration Project. Catastrophes such as an earthquake-caused dam failure or an accidental chemical spill could change Restoration Project elements, add new key uncertainties, or could even prompt the need to reconsider the Project's goals and objectives. The primary characteristic of these disturbances is that they are unpredictable and uncontrollable.

In the event of such a disturbance, the AMPT would meet and make a timely assessment of the disturbance. Included within this assessment would be 1) consideration of new and existing AMP uncertainties and conceptual models,, 2) possible changes in monitoring approaches, 3) possible adaptive responses, and depending on severity/scale of the disturbance, 4) possible reconsideration of the Restoration Project's goals and objectives. The AMPT meeting and decision-making process, including identification of responsible Parties and funding sources, would follow protocols described elsewhere in this AMP.

Monitoring Funding Contingencies

It is possible that the amount of funding available is insufficient to undertake all the recommended monitoring activities. At times where adequate funding is not available and all other AMP protocols, including the adaptive response process and those protocols specifying the Parties' responsibilities, have been met, the AMPT may prioritize which monitoring activities are completed within Contemporary funding constraints based on the following three tiers:

Funding Priority Tier I. Activities mandated under the MOU or necessary to implement activities mandated under the MOU.

Funding Priority Tier II. Activities specified within Contemporary Objectives Tables (Section III.A) including Diagnostic studies.

Funding Priority Tier III. Focused Studies and learning opportunities.

In the event of inadequate funding, studies in priority tier I would be funded before studies in tier II; tier II studies would be funded before tier III studies. Prioritization of the funding of individual studies within a tier, in the event that insufficient funding is available to fund all studies within a tier, would be based on those criteria developed for prioritizing Adaptive Management responses as described in Section III.D.8.e.

III.D.8.e. Prioritizing Response Proposals

All adaptive responses proposed by the AMTT will be prioritized by the AMPT according to Adaptive Management objectives specified in this document (Table 6) and Contemporary objectives developed through the Adaptive Management process, fisheries management strategies, effectiveness, and species and ecologically based action priorities. Balancing Adaptive Management objectives, fisheries management strategies, effectiveness, and action priorities may be very complicated and will not likely be a mere mechanical exercise that could be captured in a flow diagram.

Several criteria will be considered in prioritizing Adaptive Management responses. These criteria are not necessarily ranked, because conflicts between criteria may need to be balanced or integrated.

- Responses that promote conservation strategies, such as those promoted by federal and state endangered species laws, will take precedence over those proposals that only promote production strategies such as those embodied in the CVPIA's goal to double natural production of anadromous fish.
- The Contemporary status of salmon or steelhead populations according to federal or state endangered species laws will help determine prioritization of proposals. For example, responses benefiting species listed as endangered will take precedence over those affecting threatened, candidate, or unlisted species.
- Contemporary federal endangered species designations will take precedence over Contemporary state designations.
- Alternative response proposals that balance the needs of more than one species will take priority over response proposals focused on individual species even if otherwise equally ranked.
- Biological effectiveness will be considered when ranking response proposals. Those proposals having the maximum long-term benefit will outweigh those having only short-term benefits.
- Cost-effectiveness will be considered when ranking response proposals.
- The effect of actions on the local community and on the maintenance of renewable energy production will be considered in prioritizing Adaptive Management responses.
- Species and ecological action priorities will be used to rank responses. Responses that promote the recovery of an entire population will take precedence over those that only insure year-class success. Responses providing either of these types of benefits would outweigh those providing only protection of individuals. Finally, response proposals benefiting adult salmon or steelhead would outweigh those benefiting only juveniles.
- Although adaptive responses are generally designed to benefit salmon and steelhead populations, environmental/ecological consequences will be considered as well; the function of ecosystem processes should not be compromised to benefit only a single species.
- Responses must be technically and administratively feasible.

III.D.8.f. Budget Review

At the yearly scheduled AMPT meeting, budget reports will be received from cooperating funding sources including TNC and any agencies contributing to Adaptive

Management funding. These budget reports will be used to identify fundable Adaptive Management tasks.

III.D.8.g. Coleman National Fish Hatchery Adaptive Management

An adaptive management plan (CNFH-AMP) will be developed for the CNFH using a process inclusive of the Restoration Project AMP, responsible agencies, and interested stakeholders. USBR will facilitate development of the CNFH-AMP, which will include continued review by the CALFED Science Program Technical Review, because USBR has funding the responsibility for the CNFH. The content of past reviews will be used to assist in the development of the CNFH-AMP as was done with the Restoration Project AMP.

The Restoration Project AMP will be closely coordinated with the CNFH-AMP to share findings on key uncertainties, coordinate study designs and preliminary findings, and provide mutual assistance on activities and other items of mutual interest. Technical Teams for the AMP and the CNFH-AMP will participate in any additional technical and scientific reviews of the Restoration Project or the CNFH and the results of the reviews will be applied to each of the adaptive management programs, including necessary adjustments to accommodate the findings relevant to the programs using a watershed approach.

III.D.9. Monitoring and Data Assessment

Extensive data sets will be collected and diverse analyses will be performed in the course of implementing monitoring and data assessment under this AMP. Contemporary scientific standards, guidelines, and protocols will followed for all study design, data collection, and analysis. Furthermore, monitoring and data assessment methodologies will be standardized to the maximum extent possible with Central Valley-wide monitoring and research efforts including CAMP, CMARP, and EPA protocols.

During the course of AMP implementation, circumstances may arise that suggest changes to existing monitoring and data assessment approaches. These may include the need to refine existing approaches, budget shortfalls, emergencies, or the identification of unanticipated monitoring needs.

Refinements of existing approaches may be proposed by the AMTT if the AMTT identifies problems with existing approaches. If the proposed refinement to a monitoring or data assessment approach requires no additional funding and has no programmatic consequences, the proposed refinement may be implemented upon a Consensus decision by the AMTT. If a proposed refinement has either funding or programmatic consequences, or was proposed in response to changes in overall management approach, the AMPT would be required to approve the proposal by Consensus before the proposed change is implemented.

Two other circumstances may arise that would require a special proposal by the AMTT to the AMPT. If any budget shortfalls are encountered in the course of implementing Adaptive Management monitoring or data assessments, the AMTT would prepare, in a timely fashion, a special proposal to the AMPT. The AMPT would then meet to discuss, and possibly approve, either changes in funding or changes to the monitoring and data assessment approach, at either the AMPT's annual meeting or an ad hoc meeting.

Similarly, if an emergency arises that suggests urgent changes to monitoring or data assessment approaches, or require changes to AMP flow or facilities elements, the AMTT will convene an emergency meeting, diagnose the problem, and submit a special proposal to the AMPT. The AMPT would then consider convening an emergency meeting where it would discuss, and possibly approve, either changes in funding or changes to the monitoring and data assessment approach.

The recognizes the potential need for Diagnostic studies to pinpoint possible shortcomings in proposed restoration actions and to assist Adaptive Management. Potential Diagnostic studies identified in the AMP include diagnoses of potential fish barriers, possible problems at fish ladders, assessment of ramping effects on anadromous salmonids at the 0.1 foot/hour Ramping Rate, water temperature modeling, and instream flow modeling. It is possible that other Diagnostic studies may be required during the term of this plan. If the AMTT determines that any Diagnostic study is needed to refine an Adaptive Management approach or to determine the appropriate response to a trigger event, the AMTT will prepare a proposal for the consideration of the AMPT. No work will be initiated on Diagnostic studies without the approval and direction of the AMPT.

III.D.10. Funds Management

All decisions about funds management will be made by the AMPT at regularly scheduled meetings formally announced to the BCWC, CALFED, any person requesting such notification, and the public following the protocols listed herein. All Parties of the AMPT will jointly and aggressively pursue additional sources of funds at times when funding needs can be predetermined. The AMPT will work to conserve the CALFED Monitoring Fund to be used primarily as an emergency funding mechanism. Disbursement of money from this fund will be allocated evenly over the term of the AMP, with a budget of approximately $50,000 available per year to meet emergency needs. The balance of the fund is intended to provide a prudent reserve for unanticipated monitoring/emergencies.

III.D.11. Dispute Resolution

The MOU provides for a dispute resolution procedure that applies in the event any one of the Parties believes there is an issue regarding the interpretation of, or compliance with, any provision of the MOU including this AMP (other than an issue involving determining protocols for funding prescribed instream flow release increases utilizing the WAF or the AMF[105]), or to resolve failure to reach Consensus. Disputes involving protocols for funding prescribed instream flow release increases utilizing the WAF or the AMF[106] will be addressed later in this section. The following dispute resolution process conducted to resolve a dispute about one or more

[105] MOU 14.0
[106] MOU 14.0

Adaptive Management elements[107] is in no way intended to alter or terminate the obligations of the Parties to carry out any other Adaptive Management element identified within this AMP which is not specifically in dispute. The disputing Parties agree to devote such time, resources, and attention to the Adaptive Management process as needed to attempt to resolve the dispute at the earliest time possible.

III.D.11.a. Disputing Party – Licensee

In the event that such an issue arises, where the Licensee is the disputing Party, the Licensee shall provide written notice of that issue to each of the other Parties. The Parties will then meet within thirty (30) days of the written notice in an effort to resolve the issue. If resolution is not achieved within 14 days of the meeting, Licensee and the Resource Agencies (collectively) will each choose a person, and together those two persons will choose a single third party who will act as mediator. Choosing a mediator is the sole role of both individuals. The Licensee and Resource Agencies will bear the cost, respectively, of the person they chose to select the mediator. Licensee and the Resource Agencies shall make their respective choice within fourteen (14) days from the date of any determination that resolution has not been achieved, and the third party mediator shall be chosen no later than forty-five (45) days from such date of determination that resolution has not been achieved. The third party mediator shall mediate the dispute during the next 60 days after their selection. The cost of the mediator shall be born equally by the Licensee and Resource Agencies. Any of these times may be extended or shortened by mutual agreement of the Licensee and Resource Agencies, or as necessary to conform to the procedure of an agency or other entity with jurisdiction over the dispute. If resolution through non-binding mediation is still not achieved, the Resource Agencies and Licensee shall petition FERC to resolve the subject dispute for those actions within FERC's jurisdiction. Any such petition shall include the administrative record of the mediation process. Resource Agencies and Licensee will be responsible for assuming their respective costs for any such FERC process. For those issues falling outside the scope of FERC's jurisdiction, where any one of the Parties fails to achieve resolution through the dispute resolution process described above, any one of the Parties may seek any available appropriate administrative or judicial remedies.[108]

III.D.11.b. Disputing Party – Resource Agency

In the event that such an issue arises, where one of the Resource Agencies is the disputing Party, the disputing Resource Agency shall provide written notice of that issue to each of the other Parties. The Parties will then meet within thirty (30) days of the written notice in an effort to resolve the issue. If resolution is not achieved within 14 days of the meeting, the disputing Resource Agency and the other Parties (collectively) will each choose a person, and together those two persons will choose a single third party who will act as mediator. Choosing a mediator is the sole role of both individuals. The disputing Resource Agency and other Parties will bear the cost, respectively, of the person they chose to select the mediator. The disputing Resource Agency and other Parties shall make their respective choice within fourteen (14) days

[107] Adaptive management elements include but are not limited to objectives, monitoring and data assessment approaches, trigger events, responses, end points, or roles and responsibilities.
[108] MOU 14.0

from the date of any determination that resolution has not been achieved, and the third party mediator shall be chosen no later than forty-five (45) days from such date of determination that resolution has not been achieved. The third party mediator shall mediate the dispute during the next 60 days after their selection. The cost of the mediator shall be born equally by the disputing Resource Agency and other Parties. Any of these times may be extended or shortened by mutual agreement of the disputing Resource Agency and other Parties, or as necessary to conform to the procedure of an agency or other entity with jurisdiction over the dispute. If resolution through non-binding mediation is still not achieved, the disputing Resource Agency and other Parties shall petition FERC to resolve the subject dispute for those actions within FERC's jurisdiction. Any such petition shall include the administrative record of the mediation process. The disputing Resource Agency and other Parties will be responsible for assuming their respective costs for any such FERC process. For those issues falling outside the scope of FERC's jurisdiction, where any one of the Parties fails to achieve resolution through the dispute resolution process described above, any one of the Parties may seek any available appropriate administrative or judicial remedies.[109]

III.D.11.c. Water Acquisition Fund

If Consensus regarding flow changes is not achieved by the AMTT or AMPT, Licensee and the Resource Agencies (collectively), each will choose a person, and together those two persons will choose a single third party who will act as mediator. Each Party shall make its choice within fourteen (14) days from the date of any determination that Consensus has not been achieved, and the third party mediator shall be chosen by those Parties no later than forty-five (45) days from such date of determination that Consensus has not been achieved. These times may be extended by mutual agreement of the Resources Agencies and Licensee. If Consensus through mediation is still not achieved, the Resource Agencies and Licensee reserve their right to petition FERC to resolve the subject action. Resource Agencies and Licensee will be responsible for assuming their respective costs for any FERC process.

However, in the interim, instream flow releases determined to be necessary by the Resource Agencies through the aforementioned protocols will be provided by Licensee until there is either Consensus or FERC approval of the additional instream flow releases. WAF moneys shall be used to implement consensually agreed to or FERC-approved actions, and interim actions which have been taken pending FERC action.[110]

III.D.11.d. Adaptive Management Fund

For disputes arising regarding the funding of prescribed instream flow increases, the protocols will be the same as for the WAF described above. For disputes arising regarding funding facility modifications, the protocols will the same as for the WAF described above, with two exceptions: (1) no interim action will be implemented prior to any required FERC approval of a license amendment or other necessary action by FERC; and (2) for all actions resolved by FERC, in which Licensee is in the minority opinion (opposing a proposed action expenditure), the AMF will contribute sixty percent (60%) of any resulting facility modification cost; in the

[109] MOU 14.0
[110] MOU 9.2.A.3

case of Licensee being in the majority opinion (in support of a proposed action expenditure), the AMF will contribute one hundred percent (100%) of any resulting facility modification cost.

III.E. LINKAGES WITH OTHER PROGRAMS

Although Adaptive Management may lead to full-scale restoration of a particular ecosystem, the Restoration Project does not address every activity in the entire watershed that effects the ecosystem. Other major activities in the watershed are addressed in the linkages section of the AMP. The most important restoration/management activities that require very close coordination with the Restoration Project are:

- Watershed management strategy and watershed assessment under the control of the BCWC.
- CNFH activities, primarily under control of the hatchery operator, the USFWS, with substantial involvement of the hatchery owner, the USBR. Activities include but are not limited to: 1)CALFED Science Program Workshop on Coleman Hatchery , 2) Coleman Hatchery Reevaluation (including Hatchery Genetic and Management Plan which will provide the science for the future Biological Assessment of the CNFH that will be prepared upon implementation of the Restoration Project;), 3) Reconsultation with NOAA Fisheries under ESA when Restoration Project exists, 4) Hatchery Water Intake Project , 5) Hatchery Barrier Weir, and 6) the CNFH Adaptive Management Plan.
- Sacramento River Winter-run Chinook Recovery Plan (Draft 1997) under control of NOAA Fisheries and the Technical Recovery Team. The Recovery Plan currently identifies the need for a feasibility plan for the reestablishment of winter-run Chinook. The AMPT could recommend that NOAA Fisheries facilitate development of the feasibility plan by November 2008 when the Restoration Project is expected to be fully operational. The plan could include contingencies.

This technical chapter describes the linkages between the Adaptive Management of Restoration Project elements and state, federal, and private restoration programs and directives , including CALFED Ecosystem Restoration Program's visions and Programmatic Actions, not directly related to the Restoration Project or with other Restoration Project planning that is not related to Adaptive Management. Table 27 provides a list of all the linkages discussed in this section.

III.E.1. Restoration Project Planning

This section details other planning elements of the Restoration Project to which the AMP is linked.

III.E.1.a. Memorandum of Understanding

In June 1999, PG&E, NOAA Fisheries, CDFG, USFWS, and USBR entered into a Memorandum of Understanding (MOU) that signaled the intent of these Parties to pursue a salmon and steelhead restoration effort on Battle Creek that would modify the facilities and operations FERC Project No 1121. As stated throughout this document, the AMP is a direct product of the MOU. In addition to the AMP and its elements, the MOU also described all elements of the Restoration Project including physical changes to the hydroelectric project facilities and operation; definitions; purposes; roles and responsibilities; contingencies and limitations; planning, permitting, and construction activities; funding; provisions for lease or sale of FERC Project No. 1121; environmental liabilities; dispute resolution; term; and termination. While the AMP includes many of these same elements, questions about these elements, especially when they do not pertain to Adaptive Management, should rely on wording in the MOU or the amended FERC license for this project. Any cases where the language in the AMP may conflict with the language in the MOU represents an oversight in the AMP. Therefore, the MOU prevails in any discrepancy that may be discovered between the AMP and the MOU.

III.E.1.b. Construction Monitoring

USBR agrees to perform all construction monitoring and reporting as part of construction of the Restoration Project as described in MOU Sections 6.2 and 8.4. Funding for the construction monitoring will be derived only from the federal funding as identified in MOU Section 10.2, and USBR does not agree to spend any additional, federal money to perform such construction monitoring. Construction monitoring includes those parameters required by the permits developed pursuant to the Clean Water Act, and mitigation actions adopted pursuant to CEQA, NEPA, ESA, and related FERC requirements.[111]

III.E.1.c. Facilities Transfer Agreement

USBR agrees to perform all start-up and acceptance testing and prepare the necessary documents and reports, up to and until Licensee and USBR jointly determine that the constructed facilities' operation meets the design criteria. Completion inspections for each construction contract will be performed by both USBR and Licensee and certifications of approval will be issued jointly by USBR and Licensee. If construction of a particular Restoration Project feature does not meet with the satisfaction of either party, a checklist of needed work prior to the certification of completion will be prepared and agreed to by both Parties. Upon mutual agreement of the Parties, a completed portion of the construction contract or a Restoration Project feature may be turned over to Licensee for operation and maintenance.

Start-up and acceptance testing for both screens and ladders will include, but is not limited to, measurements of velocity and flow collected from each component of the structure at several stage heights to evaluate actual hydraulic performance and reliability over the full range of operating conditions as compared to the design specifications.[112]

[111] MOU 7.1.A
[112] MOU 7.1.B

Table 27. Linkages between the Adaptive Management of the Restoration Project and other planning or restoration programs and directives.

Restoration Project Planning
CALFED Ecosystem Restoration Plan under the CALFED Record of Decision Memorandum of Understanding Construction Monitoring Facilities Transfer Agreement Facilities Monitoring Plan Operations and Maintenance Plan
Non-Project Restoration Programs In Battle Creek
Greater Battle Creek Watershed Strategy Conservation easements and conservation water rights Proposed fisheries management plan for the upper Sacramento River and tributaries Sacramento Corridor Habitat Restoration Assessment Coleman National Fish Hatchery, water-supply intake modifications Proposed Coleman Powerhouse tailrace barrier construction Modifications to the Coleman National Fish Hatchery Barrier Weir and Associated Fish Ladders Coleman National Fish Hatchery Biological Assessment and Associated Biological Opinion Coleman National Fish Hatchery Adaptive Management Plan Planning for recovery of ESA-listed species in Battle Creek
Regional Restoration Programs and Directives
CALFED Ecosystem Restoration Program. CALFED Science Program Central Valley Project Improvement Act Anadromous Fish Restoration Program Comprehensive Assessment and Monitoring Program Recovery plans for threatened or endangered salmonids Central Valley Salmon and Steelhead Restoration and Enhancement Plan Upper Sacramento River Fisheries and Riparian Habitat Management Plan Restoring Central Valley Streams- A Plan for Action Steelhead Restoration and Management Plan for California. Delta and Sacramento River operations and monitoring Reference Watersheds U.S. Bureau of Land Management U.S. Forest Service Sport and commercial fisheries management
Battle Creek Watershed Conservancy
Local community participation Sediment quality monitoring Watershed assessment Water temperature and climate monitoring Data management and dissemination
Non-Project Restoration Emergencies
For example, hazardous spills/toxic leaks

III.E.1.d. Facilities Monitoring Plan

Licensee, in consultation with the Resource Agencies, shall prepare a detailed facility monitoring plan to be submitted to FERC as part of the license amendment application. Licensee shall perform and assume the costs for the following facility monitoring:

A. At the various outlet and spillway works for North Battle Creek Feeder, Eagle Canyon, Inskip, and Asbury Pump (Baldwin Creek) Diversion Dams, operate properly calibrated remote sensing devices that continuously measure and record total flow and the fluctuation of stage immediately below each dam during all operations for the purpose of verification of FERC license compliance. All flow and stage recording methodologies shall be approved by FERC;

B. At the fish ladders at North Battle Creek Feeder, Eagle Canyon, and Inskip Diversion Dams, operate properly calibrated remote sensing devices that continuously monitor water surface elevations at the top and bottom of the ladder to identify debris problems. In addition, continuously operate a calibrated automated fish counter or an underwater video camera to document fish movement through the ladder during the initial three-year period of operation, or as otherwise agreed upon by the Parties; and

C. At the fish screens at North Battle Creek Feeder, Eagle Canyon, and Inskip Diversion Dams, operate properly calibrated remote sensing devices that continuously monitor water surface elevation differences on the inlet and outlet side of screens to identify plugging.[113]

III.E.1.e. Operations and Maintenance Plan

USBR will work with Licensee as part of the design effort to create a Operations and Maintenance Plan that will be turned over to the Licensee at the time the restoration facilities are transferred from USBR to Licensee. The Operations and Maintenance Plan will include designers' operation criteria that give standards for safety and performance limits for the new restoration facilities and a manual of standard operating procedures which explains how to operate the new restoration facilities.

III.E.1.f. Environmental Impact Statement/Environmental Impact Report

The Restoration Project Environmental Impact Statement/Environmental Impact Report (EIS/R) is a document required for compliance with both the National Environmental Policy Act (NEPA) and the CEQA. Because the Restoration Project is an action directed within the CALFED Bay-Delta Programmatic EIS/EIR (CALFED Bay-Delta Program 2000), environmental review of this EIS/R will tier from that document. The Restoration Project is also directed by several actions needed to implement the CALFED Ecosystem Restoration Program. The purpose this EIS/R is to disclose the impacts associated with the Restoration Project

[113] MOU 7.2

proposed action alternative and other project alternatives to reach a decision on the alternative to be implemented.

III.E.1.g. Action-Specific Implementation Plan

The Restoration Project Action-Specific Implementation Plan (ASIP) is a CALFED document that serves as the biological assessment for compliance with Section 7 of the ESA and the Natural Community Conservation Plan for compliance with the CESA and the California Natural Community Conservation Planning Act (NCCPA). The ASIP tiers from the programmatic CALFED Multi-Species Conservation Strategy and is consistent with the requirements of other programmatic CALFED compliance documents and agreements. The ASIP includes the adaptive management process and as such the AMP is part of, and appended to, the ASIP.

III.E.2.Non-Project Restoration Programs in Battle Creek

III.E.2.a. Conservation Easements and Conservation Water Rights

TNC has established three conservation easements and one fee acquisition within the Battle Creek watershed as of January 2004 and is talking with several other landowners at this time about possibly acquiring others. The intended goals of this project are to limit future impacts of landscape fragmentation, instream physical disturbance, the addition of new wells and septic systems; and to preserve high quality riparian habitat adjacent to wildlife compatible agriculture. TNC hypothesizes that the purchase of conservation easements in a watershed with at-risk native species will help maintain and enhance functional upland habitat, riparian habitat, and stream-bank conditions, and will help minimize threats which stem from extensive human impacts, including water use.

TNC believes that the next important step in protecting salmon and steelhead along Battle Creek is protecting the relatively pristine upland and riparian habitat along the stream from fragmentation and degradation and preventing the loss or degradation of its cold spring waters. In this project, TNC, working in partnership with the BCWC, plans to acquire conservation easement interests from willing landowners on resource-rich Battle Creek properties with potential for future development in order to provide conservation protection of natural processes while maintaining land in private agricultural use and ownership. It is intended that the terms of the easements will help ensure protection of the upland and riparian habitat, will help prevent excessive water extraction and use, and will help ensure connectivity of the stream to the surrounding land, but may vary slightly to fit a particular property.

The U.S. Bureau of Land Management (BLM) has also acquired conservation easements on two properties in lower Battle Creek including land along the mouth of the stream. The purpose of these easements, acquired in October 2000, is to conduct riparian restoration activities along Battle Creek and the Sacramento River and to maintain the agricultural nature of these properties. BLM will be developing a conservation plan for these properties and anticipates implementing restoration activities during the next 15 to 20 years. While BLM is not actively seeking other conservation easements or land acquisitions in the Battle Creek watershed at this time, they will entertain proposals by willing sellers for new acquisitions or easements in the future.[114] The BCWC and local landowners have predicted that BLM land acquisition would increase public access to Battle Creek and likely heighten human impacts on sensitive populations of salmon and steelhead (R. Lee and B. McCampbell, presentations to the BCWG, 1998).

The California Wildlife Conservation Board and CALFED is currently exploring opportunities to obtain from willing sellers, conservation water rights from cold-water sources. These conservation water rights would allow the natural flow of cold-water from springs or seeps into the natural Battle Creek stream channel.

III.E.2.b. U.S. Forest Service

All U.S. Forest Service (USFS) lands in the watershed are located in the upper Battle Creek watershed, upstream of the Restoration Project Area and outside the area that will be adaptively managed. However, the upper watershed is important in that its condition can potentially influence the quality of aquatic habitat in downstream reaches. The Lassen National Forest administers the federal lands in the upper Battle Creek watershed. Under federal direction (Sierra Nevada Forest Plan Amendment, 2001), this portion of the watershed is designated as "key" and, thus, receives priority for protection and restoration of habitat for the benefit of anadromous fish. Restoration and improvement goals include reducing accelerated erosion, restoring riparian vegetation, improving aquatic passage at road crossings, and reducing excessive fuel loads throughout the upper watershed. Inventory of streams, riparian areas, sediment sources, aquatic passages, and fuel loads were initiated in 2000, resulting in recommended management actions from data analysis to improve upper watershed conditions. Management activities that have been implemented in the recent past and planned for the near future are road relocation and decommissioning in near stream areas, road drainage improvement, stream crossing upgrades, aspen release (thinning competing conifers from aspen stands), and fuels reduction treatments.[115]

III.E.2.c. Proposed Comprehensive Fisheries Management Plan for the Upper Sacramento River and Tributaries

CDFG is beginning to draft a series of comprehensive fisheries management strategies for the upper Sacramento River and tributaries in 2001. The objective of these plans is to take a watershed-wide view at production potential and population levels of all runs of anadromous salmonids and best management practices to restore or sustain viable populations. Specific goals will be set for each upper Sacramento River tributary that will integrate the production potential of each stream, as well as the main river, from a system perspective. Perennial anadromous salmonid-producing tributaries that will be addressed in these plans include Clear, Cow, Cottonwood, Battle, Deer, Mill, and Antelope Creeks, while other streams that occasionally produce anadromous salmonids in good water years include Sulfur, Churn, and Bear Creeks. The Battle Creek strategy is currently being developed as a group effort within the BCWG as

[114] Kelly Williams, BLM, pers. comm. 10/17/00.
[115] Melanie McFarland, USFS, pers. comm. 1/29/04

part of an open planning process. Each of these watershed strategies will be developed within their respective watershed groups and will be completed in a priority order as time allows.

III.E.2.d. Sacramento Corridor Habitat Restoration Assessment

The California Department of Water Resources (CDWR) will conduct, in cooperation with BLM, CDFG, TNC, a study of the geomorphic and riparian interactions occurring on an alluvial reach of the Sacramento River between the mouth of Cow Creek and Jelly's Ferry bridge (RM 280-267), including lower Battle Creek and Anderson Creek, to determine restoration possibilities for the integrated complex that includes lands owned and managed by the BLM, lands with conservation easements held by BLM, and other possible acquisitions by fee or conservation easements from willing sellers within this reach. This work will establish the existing conditions in the river reach for quantifiable attributes that could be monitored to evaluate the effects of land use improvements.

III.E.2.e. Coleman National Fish Hatchery Water-Supply Intake Modifications

The CNFH's water-supply intakes are not adequately screened, and therefore do not currently meet federal and state guidelines for the protection of salmonids at water diversions. A process to improve the intakes has been initiated by the USFWS, and planning efforts have identified various intake alternatives to meet specific fish protection and flow requirements. A proposal for funding was submitted to CALFED during in 2001. Unfortunately, the project was not selected for funding, and funds are still being sought. Once funded, permitting, design, and construction are anticipated to take three years to complete.

Existing juvenile salmonid impingement/entrainment risks, may affect existing populations of fish in Battle Creek. Completion of the water intake screening project is expected to benefit fish in the Restoration Project Area by eliminating juvenile salmonid impingement/entrainment risks associated with the hatchery water-supply intakes.

III.E.2.f. Proposed Coleman Powerhouse Tailrace Barrier Construction

The AFRP identified the lack of a tailrace barrier downstream of the Coleman Powerhouse as a high-priority action item because of harmful false attraction of anadromous salmonids to powerhouse tailrace water (USFWS 1997). Although initially linked to proposed modifications to the CNFH water-supply intakes, unanticipated delay in the implementation of the intake screening process has lead to the independent pursuit of corrective action at this site. The remedy to prevent false attraction of salmon and steelhead out of Battle Creek and into the Coleman Powerhouse Tailrace is being actively pursued under the CVPIA's AFRP. PG&E, USFWS, DFG, and NOAA Fisheries have been coordinating, and PG&E has hired a consultant to prepare the conceptual and detailed design of the permanent fish barrier. The Parties anticipate the permanent fish barrier will be installed as soon as practicable after technical, financial and permitting issues are resolved.

III.E.2.g. Modifications to the Coleman National Fish Hatchery Barrier Weir and Associated Fish Ladders

The barrier weir at the CNFH is used primarily to congregate fall-run Chinook, late fall-run Chinook, and steelhead broodstock for the hatchery. Congregated adults are collected via a fish ladder leading to the adult holding ponds, while a second (i.e., upstream) ladder provides access to upper Battle Creek during the six months broodstock are not collected. The USFWS is presently funded by a 1999 CALFED grant to (1) more effectively block fall and late-fall Chinook passage and (2) improve the upstream fish ladder to meet the same Contemporary criteria that will be applied to the improved hydro power facility ladders. These modifications support the proposed Restoration Project. The USFWS is working with the USBR to determine the final design and future operations of this facility through the NEPA process.

Fish trapping facilities at this ladder will play an important part in several Adaptive Management objectives. Adult anadromous salmonids returning to the Restoration Project Area will be captured and sampled for such information as populations estimates, run-timing, stock, size, and condition. Future activities to monitor upstream migration of adults into the restored portion of the Battle Creek watershed can be modeled after monitoring conducted at this site by the USFWS office in Red Bluff since 1995 (USFWS 1996).

III.E.2.h. Coleman National Fish Hatchery Biological Assessment and Associated Biological Opinion

In 2001, the USFWS completed a Biological Assessment (BA) describing fish propagation programs at the CNFH and assessing potential impacts resulting from those artificial propagation programs to naturally produced salmonids. The primary purpose of the BA is to provide a single, comprehensive source of information to assess the CNFH impacts, primarily to listed fish populations, resulting from artificial production programs. The BA was submitted to NOAA Fisheries as part of the evaluation and permitting process required under section 7 of the ESA. NOAA Fisheries will use the BA to generate a Biological Opinion, which will assess whether the proposed artificial production programs impart deleterious genetic or ecological effects on listed natural populations. The organizational structure of the BA follows the highly detailed format of the NOAA Fisheries' Hatchery and Genetic Management Plan (HGMP). Furthermore, the BA is structured in a manner that incorporates and addresses comments and concerns generated through public and stakeholder participation in the CNFH re-evaluation process (USFWS 2000). The primary goal of the CNFH re-evaluation process is to objectively review all aspects of hatchery facilities and operations to ensure compatibility with efforts to restore healthy populations of naturally produced salmonids in Battle Creek. The four major components of the re-evaluation process are:

- Compilation and analysis of historical hatchery operations and evaluation work;
- Determination of mitigation responsibilities;
- Analyzing potential impacts of current and proposed production programs on listed stocks of anadromous salmonids; and,

- Generating and analyzing potential management alternatives to reduce negative impacts on naturally produced salmonid populations in an Adaptive Management framework.

This broadly focused re-evaluation process is in addition to ongoing monitoring and evaluations that are conducted by the USFWS' Hatchery Evaluation program at the Red Bluff Fish and Wildlife Office (e.g., biological investigations, monitoring, and hatchery permitting biological assessments and enhancement permits).

Through an adaptive management program incorporating the several ongoing processes of monitoring and assessing hatchery operations, the USFWS will continue to investigate concerns regarding hatchery programs and activities that could affect restoration of naturally produced populations of anadromous salmonids in Battle Creek. In cases where negative impacts are shown to exist, the USFWS will investigate alternative strategies or facility designs to reduce or eliminate those impacts. Future modifications to hatchery activities or facilities may necessitate re-initiation of consultation with NOAA Fisheries, amending or revising the BA for the CNFH, or formal NEPA/CEQA proceedings

III.E.2.i. Coleman National Fish Hatchery Adaptive Management Program

An adaptive management plan (CNFH-AMP) will be developed for the CNFH using a process inclusive of the agencies responsible for the Restoration Project AMP and interested stakeholders. USBR, as the owner of the CNFH, will facilitate the development of the CNFH-AMP which will include continuing review by the CALFED Science Program Technical Review. The content of past reviews will be used to assist in the development of the CNFH-AMP as was done with the Restoration Project AMP.

The CNFH-AMP will be closely coordinated with the Restoration Project AMP to share findings on key uncertainties, study designs and preliminary findings, opportunities to provide mutual assistance on activities and other items of mutual interest. As the CALFED Science Program continues to support either the Restoration Project AMP or the CNFH AMP by providing further technical and scientific review of the projects, the Technical Teams of each adaptive management plan will participate in the reviews, and the results of the reviews will be applied to each of the adaptive management programs, including necessary adjustments to accommodate the findings relevant to the programs using a watershed approach. The "goals and objectives" of the CNFH-AMP will include those of the Restoration Project and the CALFED ERP programmatic actions, in addition to legally mandated hatchery-specific goals and objectives, including those in the CBDA EIS. The CNFH-AMP is being developed such that it is compatible and similar to the scientific approaches in the Restoration Project AMP and the CALFED Science Program. Some of the main components intended for the CNFH-AMP are goals, objectives, conceptual models, uncertainties, monitoring and data assessment approaches, specification of Focused Studies, and all other elements of formal adaptive management. Operating procedures will allow for full coordination with the Restoration Project AMP as described in Section III.D.8.

III.E.3. Regional Restoration Programs

III.E.3.a. CBDA Ecosystem Restoration Program

The Restoration Project is funded in large part by monies allocated as part of the implementation phase of CBDA's Ecosystem Restoration Program (ERP). The ERP is a comprehensive plan for restoration activities in Battle Creek watershed that is at the programmatic level. The series of interrelated documents are organized into a matrix of visions that identify what the ERP will accomplish with its stated objectives, targets, and programmatic actions for an ecological process, habitat, species or species group, stressor, or geographical unit. The vision statements included in the ERP provide technical background to increase understanding of the ecosystem and its elements.[116] In light of the contribution of CBDA monies to the Restoration Project, ERP visions that are relevant to the Restoration Project, in terms of species or processes, are presented in Table 28. The adaptive management actions that will meet ERP visions will be identified.

The visions and actions within Battle Creek include Coleman Hatchery, PG&E's Hydroelectric Project and Watershed Planning and they are summarized in Section XIII as excerpts from the documents. All projects developed in each of these program areas using environmental documents that are tiered off the CALFED Record of Decision will have to consider the visions and be within the programmatic actions specified in the ERP.

CALFED Science Program

The ERP coordinates with the Science Program to incorporate review, insights, and advice from independent science experts to ensure that the best possible scientific information guides decision-making within the ERP and within programs linked to the ERP. Providing science relevant to decision making requires two things: building a conduit between experts and managers so the most current knowledge relevant to a problem can be directly communicated, and providing an unbiased scientific review of information gathered to define and evaluate program activities. Oversight of data collection and ecosystem monitoring, along with scientific review of assumptions underlying program strategies and the effects of program actions is essential. To cite the ROD, "The highest quality and credibility of science-based decision making will be assured by the integration in the Program of an independent board of scientific experts." The Science Program's involvement in both the Restoration Project AMP and the CNFH-AMP will be closely coordinated and will be communicated among the staff for each of the adaptive management programs.

The Science Program is currently developing aquatic and terrestrial baseline monitoring programs to provide information needed by managers and scientists to follow trends in key indicators of the status and trends of Bay/Delta and Central Valley ecosystems and several sensitive plant and animal species. Geographically, the recommended aquatic resources baseline program will extend from the bases of the major dams through the Bay/Delta and into the nearshore ocean. The program will include ecosystem processes as well as specific elements

[116] CALFED ERP Volume 1 page 1

directed to listed and special status fish species such as Chinook salmon, steelhead, delta smelt, splittail, and green and white sturgeon.

The foundation of the proposed baseline will be built on many of the existing monitoring efforts being conducted under the auspices of CVPIA, CAMP, the Interagency Ecological Program, the Sacramento Watershed Group, the San Francisco Estuary Institute's Regional Monitoring Program, and agency-funded tributary monitoring on the Feather, American, and Tuolumne Rivers and on Battle, Deer, Mill, and Butte Creeks. The monitoring program report will identify data gaps and recommend new elements to fill those gaps.

Monitoring and data assessment results from the Battle Creek Adaptive Management program will be shared with the Science Program. Data collections and analyses as part of the AMP will be coordinated with the larger aims of the ERP and Science Programs.

Table 28. CBDA Ecosystem Restoration Program visions for ecosystem elements and how the Restoration Project and AMP achieves these visions.

Element	ERP Vision	Achievement Method
Central Valley Streamflows	The ERP vision for Central Valley streamflows is to protect and enhance the ecological functions that are achieved through the physical and biological processes that operate within the stream channel and associated riparian and floodplain areas in order to contribute to the recovery of species and the overall health of the Bay-Delta.	The Restoration Project will substantially increase stream flows to meet the needs of ERP priority 1 fish species, Chinook salmon and steelhead. The AMP contains protocols for changing these stream flows if necessary to increase Chinook salmon and steelhead populations, Chinook salmon and steelhead habitat, or assist Chinook salmon and steelhead passage.
Stream Meander	The ERP vision for stream meander is to conserve and reestablish areas of active stream meander, where feasible, by implementing stream conservation programs, setting levees back, and reestablishing natural sediment supply to restore riverine and floodplain habitats for fish, wildlife, and plant communities.	By removing several diversion dams from Battle Creek, the Restoration Project will aid in the reestablishment of active stream meanders to the extent that Battle Creek and its tributaries meander naturally. Furthermore, agreements between Licensee and CDFG regarding enhancing the natural sediment supply and sediment routing in Battle Creek have been formalized in the past and will be pursued in the future.
Natural Floodplains and Flood Processes	The ERP vision for natural floodplains and flood processes is to conserve existing and intact floodplains and modify or remove barriers to over-bank flooding to reestablish aquatic, wetland, and riparian floodplain habitats.	By removing several diversion dams from Battle Creek, the Restoration Project will aid in the reestablishment of natural floodplains and flood processes, even though the FERC Project No. 1121 has historically had a relatively minor effect on natural flood flows.

Element	ERP Vision	Achievement Method
Coarse Sediment Supply	The ERP vision for coarse sediment supply is to provide a sustained supply of alluvial sediments that are transported by rivers and streams and distributed to river bed deposits, floodplains, channel bars, riffles, shallow shoals, and mudflats, throughout the Sacramento-San Joaquin Valley, Delta, and Bay regions. This would contribute to habitat structure, function, and foodweb production throughout the ecosystem.	By removing several diversion dams from Battle Creek, the Restoration Project will prevent the loss of naturally supplied sediment that can be stored in reservoir impoundments or removed from the system by reservoir dredging operations.
Central Valley Stream Temperatures	The ERP vision for Central Valley stream temperatures is to restore natural seasonal patterns of water temperature in streams, rivers, and the Delta to benefit aquatic species by protecting and improving ecological processes that regulate water	The Restoration Project will substantially increase instream flows, increase spring releases from hydroelectric project water collection facilities, and remove interbasin transfers of water to restore natural seasonal patterns of water temperatures in Battle Creek by protecting and improving ecological processes that regulate water. Furthermore, the AMP contains protocols for changing these stream flows if necessary to meet appropriate water temperature criteria.
Riparian and Riverine Aquatic Habitats	The ERP vision for riparian and riverine aquatic habitats is to increase their area and protect and improve their quality. Achieving this vision will assist in the recovery of special-status fish and wildlife populations and provide high-quality habitat for other fish and wildlife dependent on the Bay-Delta. The ERP vision includes restoring native riparian communities ranging from valley oak woodland associated with higher, less frequently inundated floodplain elevations to willow scrub associated with low, frequently inundated floodplain elevation sites such as stream banks, point bars, and in-channel bars.	By removing several diversion dams from Battle Creek, increasing instream flows, and increasing cold-water spring releases from hydroelectric project water collection facilities, the Restoration Project will improve riparian and riverine aquatic habitats. It is believed that higher instream flows will aid in the distribution of seeds from riparian plant species and elevate the dry-season water table in the riparian area fostering an expansion of riparian communities such as willow scrub.
Freshwater Fish Habitats	The ERP vision for freshwater fish habitats is to protect existing habitat from degradation or loss, to restore degraded habitats, and restore areas to a more natural state. Freshwater fish habitat will be increased to assist in the recovery of special-status plant, fish, and wildlife populations. Restoration will provide high-quality habitat for other fish and wildlife dependent on the Bay-Delta.	By removing several diversion dams from Battle Creek, increasing instream flows, and providing improved fish passage facilities, the Restoration Project will restore degraded freshwater fish habitats to assist in the recovery of special-status plant, fish, and wildlife populations.

Element	ERP Vision	Achievement Method
Essential Fish Habitats	The ERP vision for essential fish habitats is to maintain and improve the quality of existing habitats and to restore former habitats in order to support self-sustaining populations of Chinook salmon.	By removing several diversion dams from Battle Creek, increasing instream flows, increasing cold-water spring releases from hydroelectric project water collection facilities, and providing improved fish passage facilities, the Restoration Project will restore degraded freshwater fish habitats to assist in the recovery of self-sustaining populations of four races of Chinook salmon.
Winter-Run Chinook Salmon	The ERP vision for winter-run Chinook salmon is to recover this state and federally listed endangered species, achieve naturally spawning population levels that support and maintain ocean commercial and ocean and inland recreational fisheries, and that fully uses existing and restored habitats. This vision will contribute to the overall species diversity and richness of the Bay-Delta system and reduce conflict between protection for this species and other beneficial uses of water and land in the Central Valley.	By removing several diversion dams from Battle Creek, increasing instream flows, increasing flows from cold-water springs, and providing improved fish passage facilities, the Restoration Project will restore degraded freshwater fish habitats to assist in the recovery of self-sustaining populations of winter-run Chinook salmon. Fish passage facilities and prescribed minimum instream flows were determined in large part based on the needs of winter-run Chinook salmon. Furthermore, the AMP contains protocols for changing these stream flows if necessary to specifically meet the habitat needs of winter-run Chinook salmon.
Spring-Run Chinook Salmon	The ERP vision for spring-run Chinook salmon is to recover this state and federally listed threatened species under the ESA, achieve naturally spawning population levels that support and maintain ocean commercial and ocean and inland recreational fisheries, and that fully use existing and restored habitats. This vision will contribute to the overall species diversity and richness of the Bay-Delta system and reduce conflict between protection for this species and other beneficial uses of water and land in the Central Valley.	By removing several diversion dams from Battle Creek, increasing instream flows, increasing flows from cold-water springs, and providing improved fish passage facilities, the Restoration Project will restore degraded freshwater fish habitats to assist in the recovery of self-sustaining populations of spring-run Chinook salmon. Fish passage facilities and prescribed minimum instream flows were determined in large part based on the needs of spring-run Chinook salmon. Furthermore, the AMP contains protocols for changing these stream flows if necessary to specifically meet the habitat needs of spring-run Chinook salmon.

Element	ERP Vision	Achievement Method
Late fall-run Chinook Salmon	The ERP vision for late fall-run Chinook salmon is to recover this stock which is presently a candidate for listing under the ESA (it is included in the fall-run Chinook salmon evolutionarily significant unit), achieve naturally spawning population levels that support and maintain ocean commercial and ocean and inland recreational fisheries, and that fully use existing and restored habitats. This vision will contribute to the overall species diversity and richness of the Bay-Delta system and reduce conflict between protection for this species and other beneficial uses of water and land in the Central Valley.	By removing several diversion dams from Battle Creek, increasing instream flows, and providing improved fish passage facilities, the Restoration Project will restore degraded freshwater fish habitats to assist in the recovery of self-sustaining populations of late fall-run Chinook salmon. Fish passage facilities and prescribed minimum instream flows were determined in large part based on the needs of late fall-run Chinook salmon. Furthermore, the AMP contains protocols for changing these stream flows if necessary to specifically meet the habitat needs of late fall-run Chinook salmon.
Fall-Run Chinook Salmon	The ERP vision for the fall-run Chinook salmon evolutionarily significant unit is to recover all stocks presently a candidate for listing under the ESA achieve naturally spawning population levels that support and maintain ocean commercial and ocean and inland recreational fisheries, and that fully use existing and restored habitats. This vision will contribute to the overall species diversity and richness of the Bay-Delta system and reduce conflict between protection for this species and other beneficial uses of water and land in the Central Valley.	By removing several diversion dams from Battle Creek, increasing instream flows, and providing improved fish passage facilities, the Restoration Project will restore degraded freshwater fish habitats to assist in the recovery of self-sustaining populations of fall-run Chinook salmon. Fish passage facilities and prescribed minimum instream flows were determined in consideration of the needs of fall-run Chinook salmon. Furthermore, the AMP contains protocols for changing these stream flows if necessary to specifically meet the habitat needs of fall-run Chinook salmon.
Steelhead Trout	The ERP vision for Central Valley steelhead trout is to recover this species listed as threatened under the ESA and achieve naturally spawning populations of sufficient size to support inland recreational fishing and that fully uses existing and restored habitat areas.	By removing several diversion dams from Battle Creek, increasing instream flows, and providing improved fish passage facilities, the Restoration Project will restore degraded freshwater fish habitats to assist in the recovery of self-sustaining populations of steelhead. Fish passage facilities and prescribed minimum instream flows were determined in large part based on the needs of steelhead. Furthermore, the AMP contains protocols for changing these stream flows if necessary to specifically meet the habitat needs of steelhead.

Element	ERP Vision	Achievement Method
Anadromous Lampreys	The ERP vision for anadromous lampreys is to maintain and restore population distribution and abundance to higher levels than at present. The ERP vision is also to better understand life history and identify factors which influence abundance. Better knowledge of these species and restoration would ensure their long-term population sustainability.	By removing several diversion dams from Battle Creek, increasing instream flows, and providing improved fish passage facilities, the Restoration Project will restore degraded freshwater fish habitats to assist in the recovery of self-sustaining populations of anadromous lamprey. Furthermore, monitoring approaches within the AMP will contribute to gaining a better understanding of the life history identify factors which influence the abundance of anadromous lamprey.
Native Resident Fish Species	The ERP vision for resident fish species is to maintain and restore the distribution and abundance of native species, such as Sacramento blackfish, hardhead, and tule perch to contribute to the overall species richness and diversity. Achieving this vision will reduce conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta.	By removing several diversion dams from Battle Creek, increasing instream flows, and providing improved fish passage facilities, the Restoration Project will restore degraded freshwater fish habitats and should assist the restoration of the distribution and abundance of native fish species in Battle Creek.

III.E.3.b. Central Valley Project Improvement Act

The Central Valley Project Improvement Act (CVPIA) of 1992 (H.R. 429 "Reclamation Projects Authorization and Adjustments Act of 1992: Title XXXIV – Central Valley Project Improvement Act"), was enacted to provide funds for fisheries restoration. The CVPIA mandated changes in Central Valley Project (CVP) management in order to protect, restore, and enhance fish and wildlife habitat. In particular, the act stated "The mitigation for fish and wildlife losses incurred as a result of construction, operation, or maintenance of the Central Valley Project shall be based on the replacement of ecologically equivalent habitat" and that first priority shall be given to "measures which protect and restore natural channel and riparian habitat values." Restoration measures implemented as part of the Restoration Project and this AMP are consistent with CVPIA goals.

Anadromous Fish Restoration Program

To meet provisions of this act, the USFWS developed the AFRP (USFWS 1997) which identified 12 actions that would help restore anadromous fish to Battle Creek, including increasing instream flows past PG&E's hydropower diversions and installing effective fish screens and ladders. Additionally, the CVPIA has sought to minimize fish losses incurred as a result of operations or maintenance of any element of the Central Valley Project, including the CNFH in Battle Creek, and specifies that habitat replacement, rather than hatchery production, is the preferred means of mitigating for unavoidable losses.

Of the twelve proposed actions listed in the AFRP, five have been implemented, three are elements of the Restoration Project, and four are yet to be implemented (AFRP Implementation Plan available at http://www2.delta.dfg.ca.gov/afrp/). The outstanding AFRP elements include improved management of the barrier dam for salmon passage now that a disease-safe water supply has become available to the CNFH, screening the Coleman Powerhouse tailrace, screening the CNFH water-supply intakes, and developing a comprehensive restoration plan for Battle Creek that integrates the CNFH operations. These four proposed actions should be completed through the programs listed in the above Section III.E.2.

Comprehensive Assessment and Monitoring Program

The Comprehensive Assessment and Monitoring Program (CAMP) was also established in response to the CVPIA. A section of the CVPIA directed the Secretary of the Interior to develop a program to evaluate the effectiveness of actions designed to ensure that by the year 2002 the natural production of anadromous fish in Central Valley streams is sustainable, on a long-term basis, at levels not less than twice the average levels attained during 1967-1991. The anadromous species included in CAMP are fall-run Chinook salmon, late fall-run Chinook salmon, winter-run Chinook salmon, spring-run Chinook salmon, steelhead trout, American shad, striped bass, white sturgeon, and green sturgeon. The categories of anadromous fish restoration actions evaluated by CAMP for their effectiveness in doubling natural production are habitat restoration, water management, fish screens, and structural modifications.

CAMP assesses both the cumulative and relative effectiveness of restoration actions on anadromous fish production. The cumulative effectiveness of restoration actions is evaluated by monitoring adult production of each species and comparing the estimated natural adult production to the target natural adult production (i.e., the anadromous fish doubling goals). The relative effectiveness of restoration actions is evaluated by monitoring juvenile abundance of Chinook salmon in relation to when and where restoration actions are implemented. Adult and juvenile data collected for CAMP are compiled regularly and made available on the Internet and in published reports.

CAMP monitoring focuses on estimating juvenile production and counts of adults. While CAMP does fund some monitoring projects, it primarily acts as a guide to other studies by maintaining protocols for fisheries research that allow for the development of a Central Valley-wide understanding of anadromous fish restoration. Applicable data collected as part of the Restoration Project and Adaptive Management will follow CAMP protocols to facilitate the understanding of the Restoration Project contribution to reaching CVPIA goals.

III.E.3.c. Recovery Plans for Threatened or Endangered Salmonids

NOAA Fisheries prepared a draft recovery plan for winter-run Chinook salmon in 1997 which identified and set priorities for actions necessary to ultimately restore the Sacramento River winter-run Chinook salmon as a naturally sustaining population throughout its present range. More immediately, the plan identified actions to prevent any further erosion of the population's viability and its genetic integrity. The plan also contained a description of site-specific management actions necessary for recovery, including objective, measurable criteria, which when met, would allow delisting of the species, as well as estimates of the time and cost to carry out the recommended recovery measures. Finally, the draft Winter-Run Recovery Plan specified Battle Creek as a site for the potential restoration of self-sustaining populations of winter-run Chinook salmon.

NOAA Fisheries is currently in the process of developing a single final recovery plan for all three listed species (Sacramento winter-run Chinook salmon, Central Valley steelhead and Central Valley spring-run Chinook salmon). Much of this plan will likely be based on CALFED's EIS/EIR, their Multi-Species Conservation Plan, and the Ecosystem Restoration Plan. No timeline has been set for the completion of this plan.

This recovery plan may link to the Restoration Project by setting numerical goals for viable population levels for three of the species targeted for restoration. This document would likely not include any binding mandates or prescriptions to be specifically implemented in Battle Creek.

III.E.3.d. Central Valley Salmon and Steelhead Restoration and Enhancement Plan

In the early 1990s, the Central Valley Salmon and Steelhead Restoration and Enhancement Plan was developed to restore and enhance salmon and steelhead in the Central Valley (CDFG 1990). This plan called for increased instream flows and effective fish screens on Battle Creek. The implementation of the Restoration Project will meet all the recommendations in this plan that were specific to Battle Creek.

III.E.3.e. Upper Sacramento River Fisheries and Riparian Habitat Management Plan

The Upper Sacramento River Fisheries and Riparian Habitat Advisory Council's 1989 Plan singled out Battle Creek as a key watershed for restoration. Goals of this plan will be achieved with the implementation of the Restoration Project and the AMP.

III.E.3.f. Restoring Central Valley Streams - A Plan for Action

CDFG's (1993) "Restoring Central Valley Streams- A Plan for Action" focused on the potential for restoring winter-run Chinook, spring-run Chinook, and steelhead to Battle Creek by the preparation and implementation of a comprehensive restoration plan for anadromous fish in Battle Creek, increasing instream flows, and revised management of the barrier dam at the CNFH. The planning recommendations of "A Plan for Action" have already been achieved with the development of the Restoration Plan (Ward and Kier 1999a), and the MOU. Implementation of the Restoration Project and the AMP will meet "A Plan for Action's" goals of increasing instream flows. Finally, the goal of revising management of the barrier dam will be based on USFWS' HGMP for the CNFH and CDFG's proposed comprehensive fisheries management plan for the upper Sacramento River and tributaries.

III.E.3.g. Steelhead Restoration and Management Plan for California

Steelhead Restoration and Management Plan was prepared by CDFG in 1996 as a follow-up to CDFG's "A Plan for Action" stemming from the final recommendations of the California Advisory Committee on Salmon and Steelhead Trout. Several of the actions identified in this document that pertained to the Battle Creek watershed will be implemented through the Restoration Project.

III.E.3.h. Delta and Sacramento River Operations and Monitoring

Water diversions from the Sacramento River downstream of Battle Creek, including Red Bluff Diversion Dam and about 300 others, have been identified as causing problems for fish passage (CDFG 1990). Especially harmful for fish populations from the upper Sacramento River Basin are the many unscreened water diversions which can entrain juvenile and adult fish (CDFG 1990). Perhaps the most commonly cited factor negatively affecting populations of salmon and steelhead from Sacramento River tributaries such as Battle Creek is the operation of water pumping plants by state and federal agencies, as well as smaller water diversions, within the Sacramento-San Joaquin Bay-Delta (CDFG 1990). These pumps cause problems with the magnitude and direction of flow, tidal cycles, fish entrainment, salinity and water quality, and fish migration (CDFG 1990).

Seeking solutions to the resource problems in the Bay-Delta, state and federal agencies signed a Framework Agreement in June of 1994 that provided increased coordination and communication for environmental protection and water supply dependability. The Framework Agreement laid the foundation for the Bay-Delta Accord and the CALFED Bay-Delta Program. A programmatic Environmental Impact Statement was released in June 2000 which detailed specific actions regarding how water supply operations will be coordinated with endangered species protections and water quality, and which developed long-term solutions to fish and wildlife, water supply reliability and flood control, and water quality problems in the Bay-Delta.

The well intended steps proposed in these planning documents may have beneficial effects on fish populations from Battle Creek and should aid the Restoration Project in restoring anadromous fish to Battle Creek. However, it is possible that diversions in the Bay-Delta and Sacramento River will continue to harm fish populations from Upper Sacramento River tributaries. If that happens, salmon and steelhead restoration in Battle Creek could be confounded. The studies in the AMP have been designed to identify those impacts on Battle Creek fish caused by the hydroelectric project and to tell when factors from outside the watershed are at play. However, the AMP will not be able to rectify extra-watershed limiting factors.

III.E.3.i. Reference Watersheds

Reference Watersheds are other watersheds resembling Battle Creek in geology, morphology, hydrology, and fish species diversity and distribution, which are located in close proximity to Battle Creek. Knowledge of population trends in Reference Watersheds would be useful when evaluating population trends in Battle Creek to perhaps tease out within-watershed versus regional effects. In many cases, the AMP intends to employ such comparisons when they would be statistically valid.

However, finding watersheds that are directly comparable may be problematic due to the unique nature of Battle Creek and the scarcity of current statistically valid data in nearby watersheds. For example there is no other tributary to the Sacramento River that supports populations of winter-run Chinook salmon, has constantly flowing cool springs at relatively low elevations, or currently estimates juvenile Chinook salmon production.

Reference watersheds will need to meet the following criteria to be considered comparable to Battle Creek:

- Any current information from proposed Referenced Watersheds must be statistically valid for comparative analysis.
- If studies are recommended in Reference Watersheds, the study proposal will need to be coordinated with personnel responsible for fisheries management in the proposed watershed.
- The recommended future studies must have statistically valid data comparable to the target question.
- Recommended future studies in Reference Watersheds will need to be adequately funded.
- Recommended future studies in Reference Watersheds will need to be technically feasible.

III.E.3.j. Sport and Commercial Fisheries Management

The Pacific Fishery Management Council (PFMC) is responsible for managing fisheries off the coasts of California, Oregon, and Washington, including setting regulations for commercial and sport fishing activities in federal offshore waters (from 3 to 200 miles offshore of the U.S. coastline). The California Fish and Game Commission (CFGC) also sets regulations for sport fisheries, and aspects of commercial fisheries, directed at Battle Creek salmon and steelhead populations. While the harvest of Battle Creek salmon and steelhead may affect the growth of fish populations anticipated to result from implementation of the Restoration Project, this AMP does not contain provisions for adaptive harvest management and instead will depend on PFMC and CFGC to manage fisheries.

III.E.4. Battle Creek Watershed Conservancy

III.E.4.a. Potential Local Community Participation

In general, the stream systems of the upper watershed are in good health; fisheries, water, and land management activities occurring in these streams have had little affect on the potential to restore anadromous salmonids to the lower Battle Creek watershed. While several fisheries, land, and water management actions in the upper watershed affect resident populations of fish, these effects are usually localized and attenuated by the time Battle Creek flows into anadromous fish habitat. Some of these actions include fish stocking in streams and reservoirs of the upper watershed for recreational fishing, timber harvest on private and public lands primarily in the headwaters areas, cattle grazing in or near riparian ecosystems, and hydroelectric power development (Ward and Kier 1999a).

Nonetheless, several possible land use activities that could affect restoration of salmon and steelhead have been identified. Agricultural use of surface waters may affect anadromous fish habitat if water quality and temperature are affected. Catastrophic wild fires in the uplands surrounding the anadromous fish habitat of Battle Creek could devegetate vast areas of land exposing significant amounts of soil to erosive processes which might then carry sediment to fish habitat in Battle Creek (Wissmar et al. 1994; see Spence et al. 1996 for a review of the effects of wildfires on salmonids). Chemical fire retardants needed to suppress wild fires have also been identified as affecting water quality and killing fish (Norris and Webb 1989).

Furthermore, current trends throughout the American West indicate that as the economics within Battle Creek shift and as more people seek land in rural areas, it is likely that large land holdings will be subdivided and sold to multiple owners (Rudzitis 1996; Power 1996) leading to more complicated political and land management scenarios which will likely affect the ability to restore or maintain salmon and steelhead populations. The present land use and ownership patterns have been identified by CDFG as the best for the restoration of anadromous fish populations compared with the identified alternatives (CDFG 1997).

Neither the AMP nor any single agency initiative will be addressing any of these issues despite the fact that land use, and the attitudes toward restoration held by local landowners, will play a critical role in the restoration of anadromous salmonids to Battle Creek. The BCWC, in as much as it is motivated and funded to do so, will be the organization most suited to protecting Battle Creek and its fish populations from deleterious land use practices, primarily through education, outreach, physical projects, and monitoring.

Perhaps most importantly, the BCWC is best suited to foster long-term acceptance of the Restoration Project by the local community, which will be a critical component to the success of Adaptive Management and the Restoration Project. The perception of the Restoration Project by local community members ranges from "it's a government imposed burden" to "it's a worthy project that we want to help." The BCWC has long contended that local residents will be more likely to support the Restoration Project if the Project focuses on the entire watershed, including the upper and lower reaches of Battle Creek, as well as the Upper Sacramento River, and not only on the middle reaches or hydropower project. In particular, watershed residents are concerned with potential risks posed by the CNFH operations on the Restoration Project. Unless the residents are convinced that all reasonable measures are being taken to reduce the risk of failure of the Project, they are unlikely to support it. Should the project fail, many residents fear that the Resource Agencies will look toward curbing land uses and water rights in their attempts to rescue an endangered species. An overall watershed analysis, as well as an analysis of potential risks to the Project posed by the CNFH, such as the CALFED Battle Creek Science Panel Report, "Compatibility of Coleman National Fish Hatchery Operations and Restoration of Anadromous Salmonids in Battle Creek," and a reasonable and timely response from the Resource Agencies to such analysis, will help to ensure local support of the Project.

If the BCWC and the MOU Parties can work together to successfully implement the Restoration Project, the challenge will be to give members of the local community a reason to embrace the Restoration Project. The BCWC has suggested that if the local community is encouraged to participate in adaptive management monitoring and data management, community acceptance, a sense of ownership in the outcome of the project, and the eventual success of the Restoration Project is far more assured than if the Restoration Project excludes local input and salmonid restoration is seen as something to be actively resisted.

As a private organization with no statutory responsibility, the BCWC will have no responsibility to enforce provisions or policy associated with the Restoration Project. However, it may assist in a preventative role, helping to identify potential problems between land owners and Restoration Project policy, and helping to ameliorate these problems through technical assistance, assistance in getting grant money for on-the-ground work, and through liaison with the agencies. For example, landowners are often reluctant to consult with agencies charged with enforcement since they feel there is a chance they may be punished. The Conservancy can continue to act as a go-between in such cases, with the result that the issue is addressed and a problem solved.

III.E.4.b. Suggested Monitoring Tasks

Inasmuch as it is motivated and funded to do so, the BCWC, with participation from local schools, may be the organization most suited to monitoring certain aspects of the watershed that either fall within, or are complementary to, this AMP. The BCWC hopes the Parties will encourage their participation in the following activities.

Sediment Quality Monitoring

One of the most easily measured symptoms of deleterious land use practices would be an increase in sedimentation within Battle Creek. The BCWC could partner with local schools to initiate sediment quality monitoring. Through relatively simple scientific sampling regimes, young residents of the watershed could provide an early warning system for the health of the Battle Creek uplands while learning about – and forming a connection with – the unique populations of salmon and steelhead that will be restored in their watershed.

Ongoing Watershed Assessment

Sediment quality monitoring is useful in detecting erosion problems after they occur. The BCWC feels that a locally developed, long-term, watershed assessment program would be able to prevent erosion problems before they occur or, at least, before they affect stream habitat in the Restoration Project Area. By working with private landowners in the upper watershed, the BCWC could help landowners implement appropriate land-use practices that would protect against ecological impacts and would prevent the need for future regulatory actions. BCWC was funded by CVPIA to complete a watershed assessment and treatment plan of conditions in the watershed both upslope and upstream of the Restoration Project reaches. The assessment report will be completed by August 2004.

Water Temperature and Climate Monitoring

Water temperature and climate monitoring are included within this AMP and are activities that might be done efficiently and cost-effectively by the BCWC. Depending on interest by the BCWC, it may be possible for the Resource Agencies to train and fund the BCWC to collect this critical information. Some private landowners may not allow access to Battle Creek for monitoring by Resource Agency personnel, but would be much happier to allow a member of the community on their property. In these situations, it is possible that key Adaptive Management monitoring elements, like temperature monitoring, would only be feasible with the support and participation of the local community.

Data Management and Dissemination

The BCWC operates and maintains an information system in which data collected as part of the Restoration Project can be stored or disseminated. This existing system affords the BCWC and local community members the ability to monitor changes in the watershed as well as assess the effects of those changes on the fish populations and habitat in the Restoration Project Area. This system complements and, in many respects, outperforms agency-maintained databases which are designed more for Central Valley-wide applications, rather than the fine-scaled effects most important to adaptive management. The BCWC foresees using this information system as a critical way to assist in the adaptive management process. BCWC received funding from CVPIA to update the KRIS/Battle Creek information system by including the watershed assessment report data. A KRIS/Battle Creek website will be a component of this system.

IV. LITERATURE CITED

Allendorf, F. W., D. Bayles, D. L. Bottom, K. P. Currens, C. A. Frissell, D. Hankin, J. A. Lichatowich, W. Nehlsen, P. C. Trotter, and T. H. Williams. 1997. Prioritizing Pacific salmon stocks for conservation. Conserv. Biol. 11: 140-152.

Bernard, D.P., A. Gunther, E. Laychak, C. Darling. 1996. Restoring Central Valley spring-run Chinook salmon populations: Technical workshop to identify candidate programs and projects for Category III funding. Category III Steering Committee and CALFED Bay-Delta Program.

Caballero, A. 1994. Developments in the prediction of effective population size. Heredity 73: 657-679.

CACSST (California Advisory Committee on Salmon and Steelhead Trout). 1988. Restoring the balance: 1988 Annual Report. California State Capitol, Sacramento, California.

CALFED Bay-Delta Program. 1999. Ecosystem Restoration Program Plan, North Sacramento Valley Ecological Management Zone Vision. Volume II. CALFED, Sacramento, CA.

CALFED Bay-Delta Program. 2001. Ecosystem Restoration Program: Draft stage 1 implementation plan. CALFED Bay-Delta Program, Sacramento, CA.

CDFG (California Department of Fish and Game). 1990. Central Valley salmon and steelhead restoration and enhancement plan. California Dept. Fish and Game. 115 pp.

CDFG (California Department of Fish and Game). 1993. Restoring Central Valley streams: A plan for action. California Department of Fish and Game.

CDFG (California Department of Fish and Game). 1996. Steelhead restoration and management plan for California. California Department of Fish and Game. 234 pp.

CDFG (California Department of Fish and Game). 1997. Letter to interested parties from Richard Elliot, CDFG, on May 28, 1997. CDFG, Redding, California.

CDFG (California Department of Fish and Game). 1998. Report to the Fish and Game Commission: A status review of the spring-run Chinook salmon (Oncorhynchus tshawytscha) in the Sacramento river drainage. Sacramento, California. Candidate Species Status Report 98-01.

CDFG (California Department of Fish and Game). 2001. Battle Creek Salmon and Steelhead Restoration Project stranding and isolation survey on South Fork of Battle Creek, March 8 and 9, 2000. Memorandum to Battle Creek files, California Department of Fish and Game, Redding, CA. 7 p.

Crow, J. F., and M. Kimura. 1970. An introduction to populations genetics theory. Harper & Row, New York, 591 p.

Franklin, I. R. 1980. Evolutionary change in small populations. In M. E. Soulé and B. A. Wilcox (eds.), Conservation Biology, An Evolutionary-Ecological Perspective, p. 135-149. Sinauer Associates, Sunderland, MA.

Gresh, T, J. Lichatowich, and P. Schoonmaker. 2000. An estimation of historic and current levels of salmon production in the Northeast Pacific Ecosystem: Evidence of a nutrient deficit in the freshwater systems of the Pacific Northwest. Fisheries, 25:15-21.

Hallock, R.J. 1987. Sacramento River system salmon and steelhead problems and enhancement opportunities. California Advisory Committee on Salmon and Steelhead Trout. 92 pp.

Hartl, D. L., and A. G. Clark. 1989. Principles of Population Genetics. Sinauer Associates, Sunderland, MA, 682 p.

Healey, M. 2001. Draft comments on the Battle Creek Adaptive Management Plan. CALFED Independent Science Board. Sacramento, CA. 8 pp.

Healey, M. C. 1991. The life history of Chinook salmon (Oncorhynchus tshawytscha). In C. Groot and L. Margolis (eds.), Life history of Pacific salmon, p. 313-393. University of British Columbia Press, Vancouver, B. C.

Healey, M. C., and A. Prince. 1995. Scales of variation in life history tactics of Pacific salmon and the conservation of phenotype and genotype. Am. Fish. Soc. Symp. 17: 176-184.

Lande, R. 1995. Mutation and Conservation, p. 782-791. Conserv. Biol.

Lynch, M. 1990. Mutation load and the survival of small populations. Evolution 44: 1725-1737.

McElhany, P., M.H. Ruckelshaus, M.J. Ford, T.C. Wainwright, and E.P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. U.S. Dept. Commer., NOAA Tech. Memo. NOAA Fisheries-NWFSC-42,156 p.

Nelson, K., and M. Soulé. 1987. Genetical conservation of exploited fishes. Pages 345–368 in N. Ryman and F. Utter, editors. Population genetics and fishery management. University of Washington Press, Seattle.

NOAA Fisheries (National Marine Fisheries Service). 1997. Proposed recovery plan for the Sacramento River winter-run Chinook salmon. NOAA Fisheries, Long Beach, California.

NOAA (National Oceanographic Atmospheric Administration). 1994. Endangered and threatened species; status of Sacramento River winter-run Chinook salmon. Federal Register 59:2(January 4, 1994):440-450.

Norris, L.A. and W.L. Webb. 1989. The effects of fire retardant on water quality. Pages 79-86 In: N.H. Berg, editor. Proceedings of the symposium on fire and watershed management. General Technical Report PSW-109. U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station, Berkeley, California.

Odum, E.P. 1983. Basic ecology. CBS College Publishing, Philadelphia, PA.

Power, T.M. 1996. Lost landscapes and failed economics: the search for a value of place. Island Press, Covelo, California.

Rieman, B. E., and J. B. Dunham. 2000. Metapopulations and salmonids: a synthesis of life history patterns and empirical observations. Ecology of Freshwater Fish 9:51–64. Rieman, B. E., and J. D. McIntyre.

Rieman, B.E. and F.W. Allendorf. 2001. Effective Population Size and Genetic Conservation Criteria for Bull Trout. North American Journal of Fisheries Management 21:756–764

Rudzitis, G. 1996. People, ecosystems, and the changing American West. Columbiana Magazine, No. 19.

Shrimpton, J.M. and D.D. Heath. 2003. Census vs. effective population size in Chinook salmon: large- and small-scale environmental perturbation effects. Molecular Ecology 12, 2571–2583.

Soulé, M. E. 1980. Thresholds for survival: maintaining fitness and evolutionary potential. In M. E. Soulé and B. A. Wilcox (eds.), Conservation Biology., p. 151-170. Sinauer Associates, Inc., Sunderland, MA.

Spence, B.C., GA Lomnicky, R.M. Hughes, and R.P. Novitzki. 1996. An ecosystem approach to salmonid conservation. TR-4501-96-6057. ManTech Environmental Research Services Corp., Corvallis, OR. (Available from the National Marine Fisheries Service, Portland, Oregon.)

Stockner, J.G., E. Rydin, and P. Hyenstrand. 2000. Cultural oligotrophication: Causes and consequences for fisheries resourses. Fisheries, 25:7-14.

Technical Review Panel. 2004. Compatibility of Coleman National Fish Hatchery Operations and Restoration of Anadromous Salmonids in Battle Creek. Report of The Technical Review Panel. California Bay-Delta Authority, January 24, 2004

TRPA (Thomas R. Payne and Associates). 1998a. A 1989 instream flow study: 1 of 8 components. Prepared for California Department of Fish and Game.

TRPA (Thomas R. Payne and Associates). 1998b. A 1989 survey of barriers to the upstream migration of anadromous salmonids: 1 of 8 components. Prepared for California Department of Fish and Game.

TRPA (Thomas R. Payne and Associates). 1998c. A 1989 temperature model of lower Battle Creek, Eagle Canyon and Coleman Diversions to Coleman Powerhouse: 1 of 8 components. Prepared for California Department of Fish and Game.

TRPA (Thomas R. Payne and Associates). 1998d. A 1989 temperature model of upper Battle Creek, Al Smith Diversion to Eagle Canyon Diversion on North Fork Battle Creek and South Diversion to Inskip Powerhouse on South Fork Battle Creek: 1 of 8 components. Prepared for California Department of Fish and Game.

TRPA (Thomas R. Payne and Associates). 1998e. Draft: A 1989 study of fish species abundance and distribution in Battle Creek: 1 of 8 components. Prepared for California Department of Fish and Game.

Tu, S. 2001. Stream temperature model for the Battle Creek Salmon and Steelhead Restoration Project. PG&E, San Ramon, CA.

USBR (U.S. Bureau of Reclamation). 1998. Environmental assessment for temporary reduction in water diversions from Battle Creek. U.S. Bureau of Reclamation, Sacramento, California. USFWS 1995.

USFWS (U.S. Fish and Wildlife Service). 1994. Action plan for fishery resources and aquatic ecosystems. USFWS, Washington, D.C.

USFWS (U.S. Fish and Wildlife Service). 1995. Working paper on restoration needs: habitat restoration actions to double natural production of anadromous fish in the Central Valley of California. Volumes 1-3. May 9, 1995. Prepared by the U.S. Fish and Wildlife Service under direction of the Anadromous Fish Restoration Core Group. Stockton, California.

USFWS (U.S. Fish and Wildlife Service). 1997. Revised draft restoration plan for the anadromous fish restoration program: a plan to increase natural production of anadromous fish in the Central Valley of California. Prepared by USFWS and the Anadromous Fish Restoration Program Core Group. Sacramento, California.

USFWS (U.S. Fish and Wildlife Service). 1998. Kevin Niemela will provide citation for CNFH Ozonator EIS.

USFWS (U.S. Fish and Wildlife Service). 1999. Memorandum from Assistant Project Leader, NCVFWO to Project Leader, NCVFWO dated February 26, 1999 regarding goals, objectives, and scope of the CNFH re-evaluation process. On file at USFWS, North Central Valley Fish and Wildlife Office, Red Bluff, California.

USFWS (U.S. Fish and Wildlife Service). 2000. Memorandum from Scott Hamelberg to USFWS staff dated April 14, 2000 regarding draft hatchery and genetic management plan for Coleman and Livingston Stone National Fish Hatcheries. On file at USFWS, North Central Valley Fish and Wildlife Office, Red Bluff, California.

USFWS (U.S. Fish and Wildlife Service). 2000. Statement of work for the analysis of management alternatives generated during the Coleman National Fish Hatchery Re-Evaluation process (FY2000 AFRP funded project 00-E-1). U.S. Fish and Wildlife Service, Red Bluff, CA.

USFWS (U.S. Fish and Wildlife Service). 2001a. Biological assessment of artificial propagation at Coleman National Fish Hatchery and Livingston Stone National Fish Hatchery: program description and incidental take of Chinook salmon and steelhead trout. U.S. Fish and Wildlife Service, Red Bluff, CA.

USFWS (U.S. Fish and Wildlife Service). 2001b. Anadromous fish restoration plan (drafted in 1997). U.S. Fish and Wildlife Service, Sacramento, CA.

USFWS. 1996. Escapement of hatchery-origin winter Chinook salmon to the Sacramento River, California in 1995, with notes on spring Chinook salmon in Battle Creek. Red Bluff, California. On file at USFWS, North Central Valley Fish and Wildlife Office, Red Bluff, California.

USRFRHAC (Upper Sacramento River Fisheries and Riparian Habitat Advisory Council). 1989. Upper Sacramento River fisheries and riparian habitat management plan. State of California Resources Area. 158 p.

Wainwright, T. C., and R. S. Waples. 1998. Prioritizing Pacific salmon stocks for conservation: Response to Allendorf et al. Conserv. Biol. 12: 1144-1147.

Walters. C. 1986. Adaptive management of renewable resources. McMillan Pub. Co., New York.

Waples, R. S. 1990. Conservation genetics of Pacific salmon. III. Estimating effective population size. J. Heredity 81: 277-289.

Ward and Kier 1999a. Battle Creek salmon and steelhead restoration plan. Prepared for the Battle Creek Working Group by Kier Associates under contract with Metropolitan Water District of Southern California. Sausalito, Ca. 142 pp.

Ward, M.B. and W.M. Kier. 1999b. Maximizing compatibility between Coleman National Fish Hatchery operations, management of lower Battle Creek, and salmon and steelhead restoration. Prepared for the Battle Creek Working Group by Kier Associates under contract with Metropolitan Water District of Southern California. Sausalito, Ca. 46 pp.

Washington Department of Fish and Wildlife (WDFW). 1997. Final environmental impact statement for the wild salmonid policy, 133 p.

Wissmar, R.C., J.E. Smith, B.A. McIntosh, W.L. Hiram, G.H. Reeves, and J.R. Sedel. 1994. Ecological health of river basins in forested regions of eastern Washington and Oregon. General Technical Report PNW-GTR-326. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, Oregon.

Wright, S. 1931. Evolution in Mendelian populations. Genetics 16: 97-159.

V. APPENDIX OF PROPOSED FERC LICENSE ARTICLES AFFECTED BY ADAPTIVE MANAGEMENT

This appendix will list the text of proposed FERC license articles that pertain to FERC Project No. 1121 facilities or operations that will be affected by provisions in the AMP. Contents of this appendix will be prepared in time to be included in the Draft EIR/EIS and draft license amendment.

VI. FOCUSED STUDY: SEDIMENT MONITORING PLAN

Stillwater Sciences

2855 Telegraph Avenue, Suite 400, Berkeley, CA 94705 Phone (510) 848-8098 Fax (510) 848-8398

MEMORANDUM

DATE:	February 3, 2004
FROM:	Peter Downs and Jay Stallman
SUBJECT: Battle Creek Adaptive Management Sediment Monitoring Plan	

Background

The U.S. Department of the Interior Bureau of Reclamation and the California State Water Resources Control Board have submitted the Battle Creek Salmon and Steelhead Restoration Project (Restoration Project). The Restoration Project has the goal of restoring and enhancing about 42 miles of anadromous fish habitat in Battle Creek and an additional 6 miles of habitat on its tributaries, while minimizing the loss of renewable energy produced by the Battle Creek Hydroelectric Project (Federal Energy Regulatory Commission Project No. 1121). The Restoration Project preferred alternative as described in the EIR/EIS involves removal of five dams and appurtenant facilities, installation of fish screens and ladders, installation of stream gages, and changes to instream flows (Jones and Stokes 2003).

The Restoration Project includes an adaptive management component to monitor the effectiveness of restoration actions and make additional adjustments to the Hydroelectric Project facilities and/or operations as needed (Kier Associates 2001). A Technical Review Panel (Panel), formed by the CALFED Bay-Delta Program, provided a comprehensive evaluation of the Restoration Project preferred alternative as described in the EIR/EIS. The Panel recommended increased emphasis on monitoring in the Battle Creek Restoration Project in order to: "1) identify deficiencies or critical actions for adaptive management; 2) document the degree of success of the project; or 3) identify key responses or relationships for planning and implementing similar projects throughout the region" (Borcalli et al. 2003, p. 21). The Panel specifically noted that no funds or measurements were provided for the monitoring of sediment movement at dam removal sites.

The Project Management Team for the Restoration Project agreed with the Panel's recommendations to monitor sediment dynamics following removal of the Coleman and South Fork Diversion Dams on the South Fork. Monitoring of sediment dynamics following removal of the Wildcat Diversion Dam and the Lower Ripley Creek and Soap Creek Feeder Diversion Dams however, was not considered critical due to the small amount of stored sediment and steep channel gradients. The Project Management Team's recommendations were largely in response to a sediment impact analysis and numerical model study conducted by the Bureau of Reclamation that focused on the downstream effects of removing the three largest dams (South, Coleman, and Wildcat diversion dams) on bed material size, sediment load, and stream hydraulics (Greimann 2001b). The Bureau's study concluded that the majority of sediment will be removed from storage during the first year if dam removal is followed by normal or wet years, but may take longer if dam removal is followed by dry years.

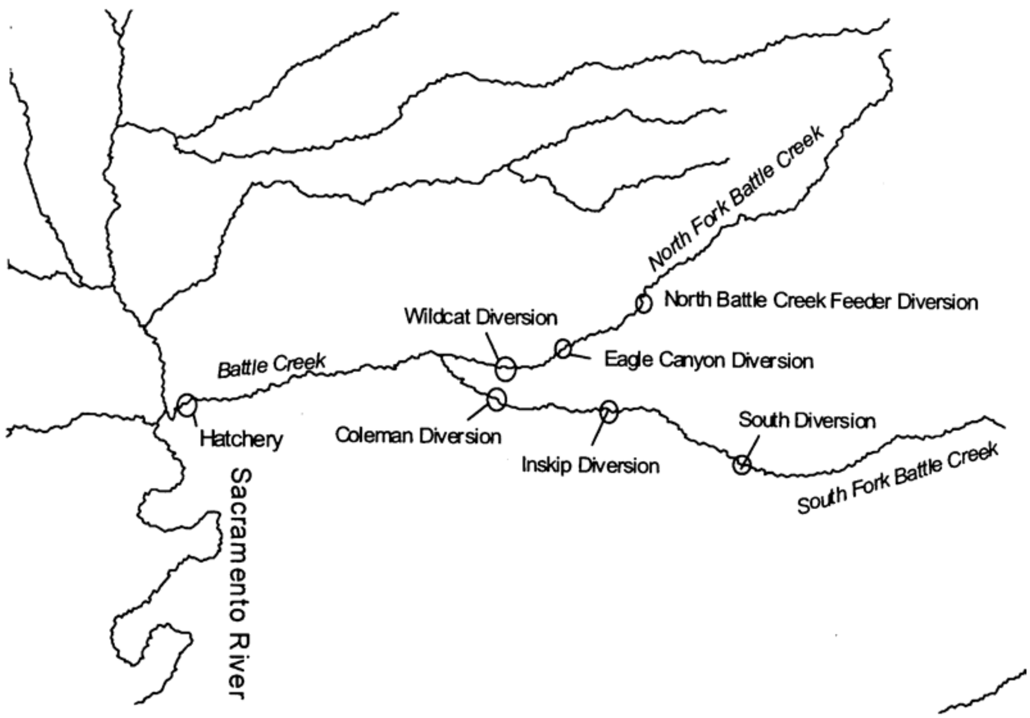


Figure 1. Map showing approximate location of diversion dams. Modified from Greimann 2001b.

Physical Setting

Battle Creek drains approximately 357 mi^2 of the southwestern Cascade Range and flows into the Sacramento River approximately 5 miles east of the town of Cottonwood. It has two main branches: North Fork Battle Creek (29.5 mi. long and drains 213 mi^2) and South Fork Battle Creek (28 mi. long and drains 124 mi^2) (Figure 1). The Battle Creek basin is predominantly comprised of young basalt flows overlain in places by interbedded lahar deposits, volcanic conglomerate, tuff, and pyroclastic debris of the Tuscan formation.

Battle Creek exhibits large spring-fed base flows due to thick snow accumulation at higher elevations and the highly permeable volcanic bedrock. Battle Creek has the largest dry-season base flow of the tributaries to the Sacramento River between Keswick Dam and the Feather River, with an average September flow of 255 cfs reaching the Sacramento River (Jones & Stokes 2003). South Fork Battle Creek is more likely to experience large peak flows from intense rainfall, while the North Fork Battle Creek receives a greater portion of its water at high elevation from snow-melt and spring-fed runoff, and is therefore, less variable (Figure 2).

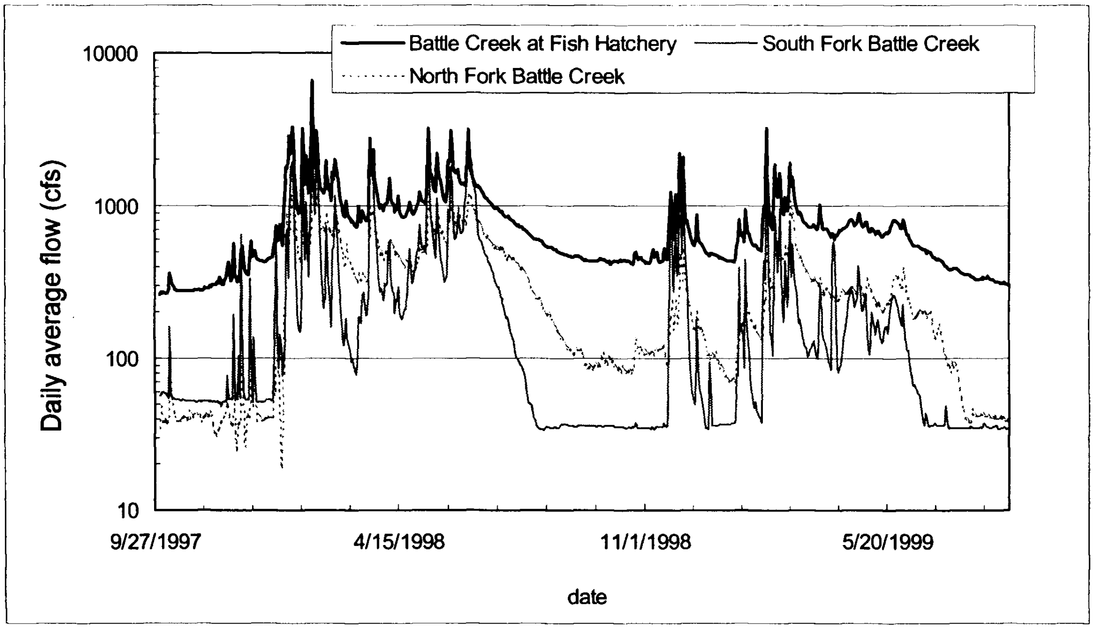


Figure 2. Daily average stream flows over the period of record for the North and South Fork stream gages as compared to the USGS gage. The flows were not corrected for diversions. Modified from Greimann 2001a.

Overall gradient of North Fork Battle Creek is approximately 0.03, while overall gradient of the South Fork Battle Creek is approximately 0.02 (Figure 3). The region upstream of South Fork Diversion Dam is steep with a slope greater than 0.03. Channel morphology is typically characterized by cobble-boulder cascades and by alternating pools and riffles that repeat every 5-7 channel widths. Periodic bars store significant amounts of coarse sediment. Sediment supply is heterogeneous, ranging from sand to boulders but with little silt or clay (Figures 4 and 5). The volume and depth of sediment trapped behind dams scheduled for removal is indicated in Table 1.

Table 1. Volume and depth of sediment stored behind dams scheduled for removal

	Eagle Canyon Diversion Dam	Wildcat Diversion Dam	South Diversion Dam	Coleman Diversion Dam
Sediment volume (cu. yd.)	3,200	5,000	30,000	28,000
Maximum depth of sediment (ft)	10	10	23	13

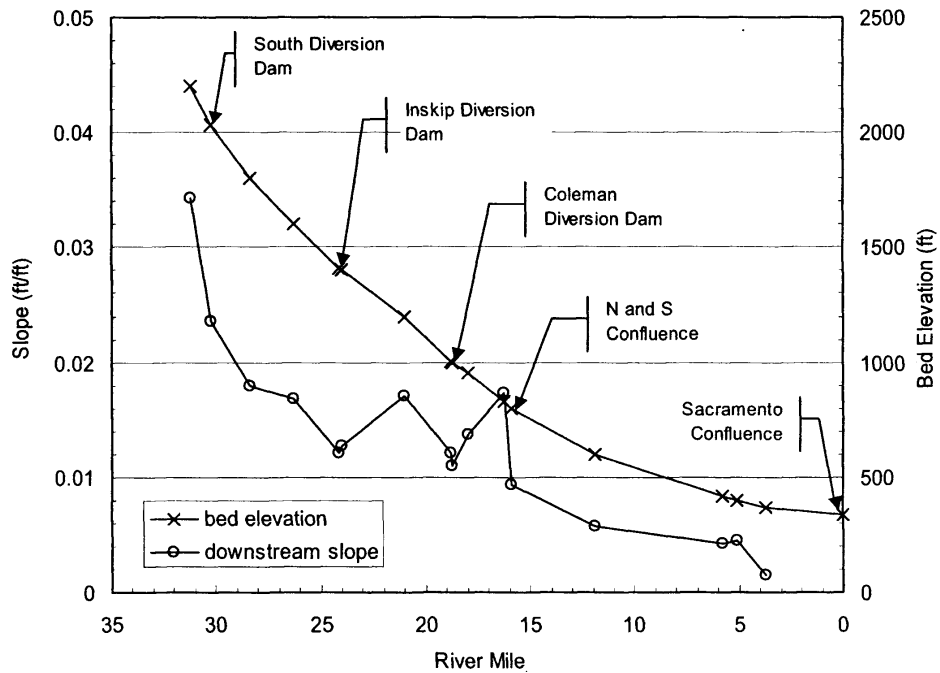


Figure 3. Bed profile of South Battle and Battle Creeks. Modified from Greimann 2001b.

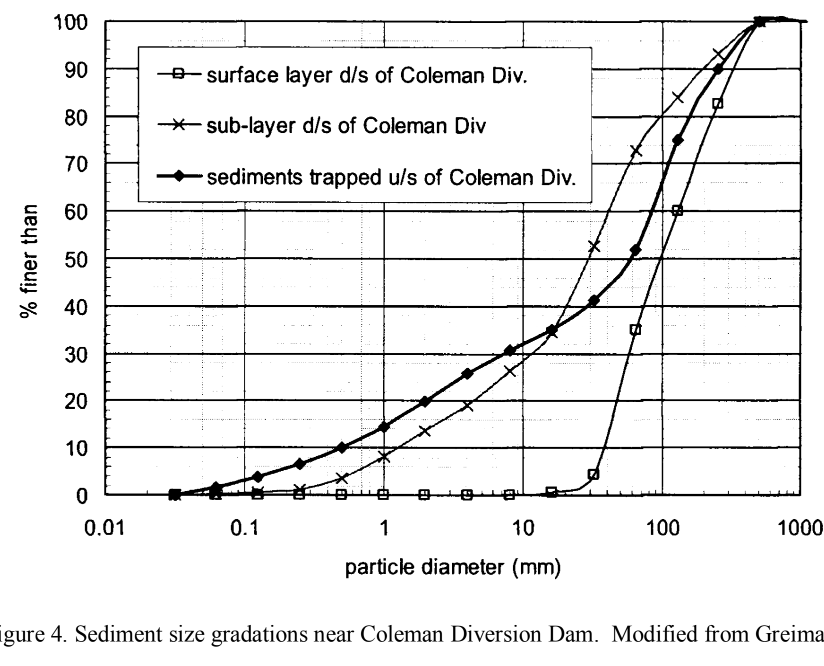


Figure 4. Sediment size gradations near Coleman Diversion Dam. Modified from Greimann 2001b.

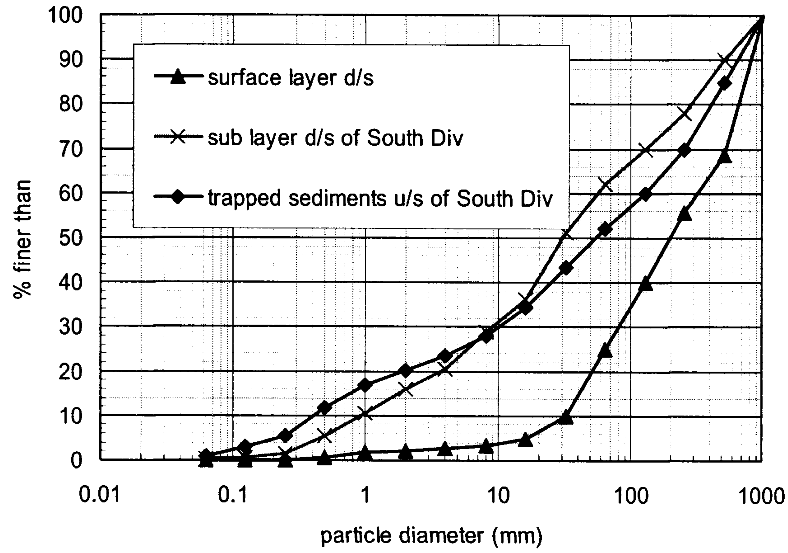


Figure 5. Sediment size gradations near South Diversion Dam. Modified from Greimann 2001b.

Uncertainties and learning opportunities from dam removal

While removal options are currently being evaluated for many dams, few dams have actually been removed and fewer still with potentially significant stores of coarse sediment. With little opportunity to study how channels respond to dam removal, there is considerable uncertainty in our knowledge of channel response. Contemporary understanding of channel response to dam removal has, in fact, often been based on investigations of the effects of other disturbances that result in rapid delivery of large amounts of sediment into the channel, such as landslides and debris flows. As such, there is a potential to learn significantly from these dam removals.

The removal of these diversion dams will release sediment stored in the existing impoundments to downstream reaches, potentially causing changes in upstream and downstream channel morphology, hydraulics, and bed surface texture. While the amount of sediment trapped behind the relatively small dams on Battle Creek may be minor, assessment of the sediment transport characteristics including the size distribution, spatial distribution, and residence time of sediment released to downstream reaches will aid in the evaluation of the success or failure of salmonid habitat restoration efforts over the short term and may require remedial management actions as part of an adaptive management program over the long term.

The current demand for cost-efficient dam removal strategies that minimize environmental impacts requires resolution of several uncertainties related to the evolution of a reservoir deposit and downstream channel reaches following sediment release. These uncertainties have direct implications for the short- and long-term success of the Battle Creek Restoration Project. Accurate prediction of sediment dynamics in rough, steep-gradient streams such as North Fork and South Fork Battle Creek, for example, is difficult using existing fractional sediment routing models due to extreme variability in hydraulic conditions and bedload transport rates. Resolution of these uncertainties therefore, requires an approach structured in empirical testing of predictive conceptual and numerical models. This approach has the greatest potential to produce transferable information about fundamental fluvial geomorphic processes if these dam removal projects are monitored appropriately. Monitoring of coarse and fine sediment downstream of proposed dam removal sites in the Battle Creek basin is therefore proposed to:

- assess sediment dynamics and associated channel morphological responses in a rough, steep-gradient channel;
- validate existing fractional sediment routing models, and potentially to compare against similar, simpler models;
- provide information to evaluate the performance of dam removals relative to habitat improvements in the Battle Creek basin,
- assess the need for adaptive management responses to changing physical conditions and;
- add to our general understanding of sediment dynamics following dam removal.

The sediment monitoring component of the adaptive management plan addresses two main areas of uncertainty:

1) *Process-form linkages*. Better conceptual models of sediment transport dynamics and channel morphological response following dam removal are needed. Removal of Wildcat Diversion dam, South Diversion dam, and Coleman Diversion dam on Battle Creek provide an opportunity to develop and test conceptual models of heterogeneous sediment release in a rough, steep-gradient channel setting. Empirical results will:

a. test current conceptual models of channel morphological change following dam removal;

b. contribute to the formulation and calibration of sediment transport models applicable to removal of individual dams in Battle Creek; information that can be used in conjunction with other investigations into the sediment impacts of dam removal (e.g. the CALFED-funded, flume-based project "*Physical Modeling Experiments to Guide River Restoration Projects*" to reduce the uncertainty in our predictive capabilities following dam removal;

c. examine the cumulative impact of multiple dam removals, for which there is currently very little information.

2) *Form-habitat linkages*. Little is known about the spatial and temporal habitat response to sediment dynamics following dam removal. Aquatic habitat may respond through:

a. short-term changes in the quantity of habitat in response to deposition and erosion during large bed-mobilizing flows that redistribute formerly impounded coarse sediment;

b. short-term changes in the textural quality (i.e., grain size distribution) of spawning habitats in response to selective fine sediment transport during lower flows;

c. Long-term evolution of the quantity and quality of spawning, rearing, and holding habitats as the formerly impounded sediments redistribute downstream during different water year types.

Uncertainties related to *habitat-biology* (e.g., population response to altered habitat conditions) and *intra-biology* linkages (e.g., biotic interactions such as predation or competition) are dealt with elsewhere in the Adaptive Management Plan.

Conceptual model

Hypotheses for process-form and form-habitat changes following dam removal are based on geomorphic system understanding developed from existing conceptual models. Conceptual models have only recently been developed for dam removal and, in a recent review of the effects of dam removal on river form and process, Pizzuto (2002) states that "our greatest need is to improve the ability to develop and test conceptual models that will indicate relevant processes controlling the evolution of the river following dam removal" (p.689). Currently, conceptual understanding is based on models developed to illustrate channel form and process changes caused by channel incision following straightening (Doyle et al. 2002, 2003; Wooster 2002). However, these models are probably most appropriate in fine-grained or sand-gravel based environments. Dam removals in Battle Creek offer the prospect of refining the existing models for coarse (Coleman) and very coarse (South Diversion) heterogeneous sediments where transport of stored sediment is more event-driven by flows exceeding an effective magnitude than process-driven immediately following dam removal (Pizzuto 2002; Stillwater Sciences 2002). Sediment transport scenarios modeled for Battle Creek under different flow-year types (Greimann 2001b) corroborate event-driven channel evolution.

Previous studies on sediment waves or pulses indicate that a pile of coarse grained sediment in a river evolves by dispersion rather than translation (e.g., Lisle et al. 1997, 2001; Cui et al. 2003a,b). Numerical studies on dam removal in steep gradient rivers indicate that, in addition to the general dispersion, sediment deposition downstream of the dam occurs only at reaches of low sediment transport capacity (e.g., Stillwater Sciences, 2000; Cui and Wilcox, in press; Cui et al. in press [a,b]). We believe the depositional characteristics following the removal of the dams on the Battle Creek will be similar. Due to the small amount of sediment in the reservoirs, however, deposition will be in a much smaller scale and amplitude, and deposition will most likely be in the existing pools.

The conceptual model for sediment response following dam removal on Battle Creek (Figure 6) is, therefore, driven by the increase in slope at the face of the stored sediment wedge following dam removal. Sediment is eroded from the face of the stored sediment (either on a 'process' or 'event' driven basis) causing incision by knickpoint propagation and channel widening through and potentially upstream of the stored sediment. The eroded sediment will aggrade downstream of the former dam site with finer sediments initially transported further downstream. These effects may result in reduced pool volume, fining of gravel substrates, and increased aerial extent of gravel bars. The dynamics of aggradation will depend on whether the released sediment acts as a stationary store of material that disperses over greater and greater distance through time or a translating pulse of material with limited attenuation downstream (more likely in fine-grained sediments). It is possible that habitat-related impacts (both positive and negative) will depend on which of these modes of transport dominates: translation will create significant short-term habitat changes as the sediment pulse passes, whereas dispersal may cause a less substantial but longer lasting impact due to longer sediment residence time. In steep-gradient channels, downstream sediment deposition will not be evenly distributed and may be confined to pools, the lee of boulder and bedrock flow obstructions, bars forced by planform curvature, lower-gradient channel segments, and floodplain surfaces. Some component of the finer fraction of coarse-grained sediments will deposit in pools following flow events. The length of time require to reach an equilibrium channel condition (if applicable) is a function of the sediment grain size distribution, stored sediment volume available for transport, channel gradient, and frequency of bed-mobilizing flow events. Both the form of the equilibrium channel condition and the time required to reach equilibrium following sediment release are unknown. The downstream extent and duration of the 'short-term' impact of sediment release on aquatic habitat is similarly unknown.

Hypotheses

Sediment transport dynamics: process – form linkages

1) Following dam removal, the downstream release of coarse sediments occurs primarily by dispersal (e.g. as predicted by Lisle et al. 2001) rather than by translation and progressive downstream attenuation. As such, a significant volume of sediment will be deposited as it disperses across the existing scour pool, and the effect will become undetectable a relatively short distance downstream due to attenuation and attrition of coarse sediment particles (e.g. Cui and Parker, in press).

2) Because of the relatively small amount of sediment, the evolution of the channel thalweg following dam removal may not match the predictions made by previous sediment transport modeling. This is especially true given that the estimated deposition will be mostly in existing pools, and numerical models do not have the mechanisms to reproduce the detailed features such as pool-riffle sequences and alternate bars (e.g., Cui and Wilcox, in press). However, the general trend, time needed to flush the sediment downstream, and general magnitude of deposition should be similar to model predictions.

3) The significant distance between the South Diversion and Coleman dams, the small amount of fine material stored in South Diversion and Wildcat dams, and the continuing existence of the Inskip Diversion will not result in cumulative sediment impacts from removal of multiple dams.

4) Following significant flows after dam removal, the downstream deposition of sediment released from the reservoir deposit will act primarily to (i) fill pools, (ii) enlarge and fine existing point bars in alluvial channel reaches (e.g., Coleman reach) , and (iii) deposit in backwaters and locations with hydraulic flow separation in reaches controlled by large boulder and bedrock obstruction (e.g. at channel margins and around large roughness elements in the South Diversion reach);

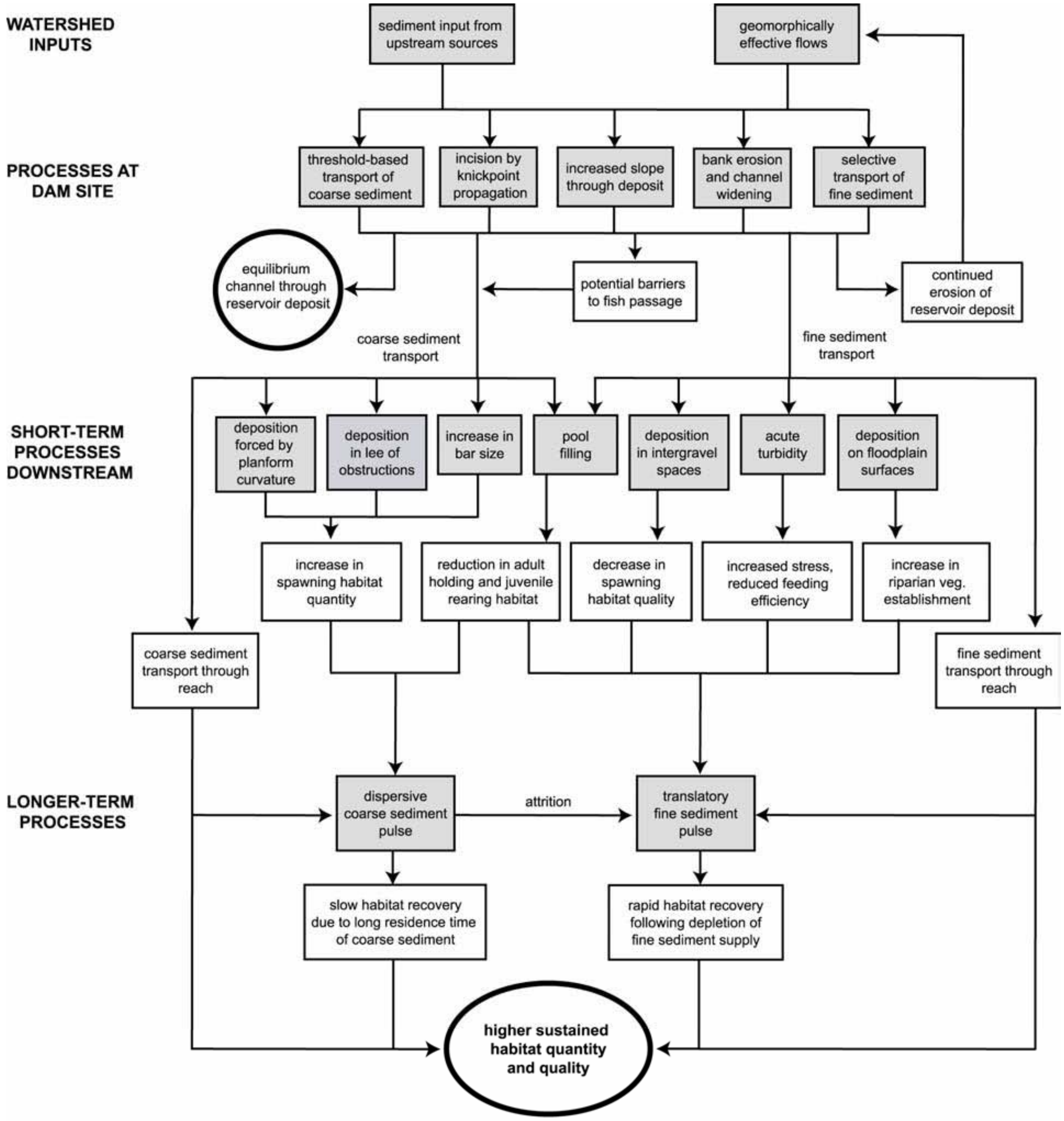


Figure 6. Conceptual model of channel response following dam removal in Battle Creek.

Channel habitat evolution: form – habitat linkages

5) Following dam removal, there will be negligible short-term effect on pool habitat downstream of the South Diversion because of the small amount of fine sediment present, and because the majority of sediment will be deposited in channel margins;

6) Availability of pool habitat downstream of the Coleman diversion will decrease in the short-term due to pool filling by sand until the upstream 'excess' supply of sand from the reservoir deposit is exhausted;

7) Removal will cause the volume of material stored in point bars and channel margins to increase and fine, facilitating encroachment by pioneer vegetation;

8) In the long-term following dam removal, there will be a notable increase in the availability of potential spawning habitat (assessed by habitat models) within South and North Fork Battle Creek to support the project's overall goals of creating a viable, self sustaining population of spring- and winter-run Chinook salmon.

Monitoring goals and objectives

The following goals and objectives form the framework for a monitoring program designed to test the hypotheses presented above:

1) Conduct field measurements necessary to describe sediment transport dynamics, aggradation, and degradation in response to sediment release following dam removal. Field surveys will be stratified so that greatest resolution is reserved for areas with the greatest potential for change

a. Characterize channel morphology and grain size distribution in project-affected reaches preceding and following dam removal.

b. Characterize sediment volume and grain size distribution in reservoir storage preceding and following dam removal.

c. Evaluate the form of sediment pulse, if any, as it propagates through downstream channel reaches over time.

2) Conduct field surveys that facilitate comparison of channel thalweg evolution to the predicted one-dimensional model simulations and to other, simpler, analytical methods developed ahead of dam removal to assess whether in situations such as Battle Creek, sophisticated model scenarios are truly warranted.

3) Relate channel morphological response to habitat values.

a. Assess short-term changes in the quality and quantity of fish habitat, and the distribution of habitat types such as pools and riffles to the initial sediment release;

b. Assess longer-term changes in the quality and quantity of fish habitat, and the distribution of habitat types such as pools and riffles during the morphological response following sediment release;

c. Relate measured and simulated changes in channel morphology, particle size distribution and velocity distribution to salmonid habitat restoration objectives set forth in the Battle Creek Salmon and Steelhead Restoration Project.

Monitoring components

The approach outlined in this sediment monitoring plan can be resolved into four geomorphic parameters, namely: 1) channel planform and surface mapping, 2) bed sediment volume and particle size surveys, 3) channel elevation surveys, and 4) sediment transport and model effectiveness evaluation. The following methods were developed to document sediment transport dynamics and channel morphology in a typical reach of Battle Creek with confined morphology, channel slopes from 0.010 to 0.025, and intermittent bedrock and large boulder controls. The methods, however, must be customized to each affected reach of Battle Creek in order to effectively detect and quantify changes in channel morphology and particle size distribution resulting from reservoir sediment release.

Monitoring should begin at least one complete water year prior to dam removal and should be tailored to management actions taken ahead of dam removal. Monitoring should be intensive during the first year following dam removal, during which time, discharge and sediment sampling should occur during each mobilizing event and surveys of channel morphology should occur after each event. Monitoring in subsequent years should be based on periodic surveys following flow events of specified magnitude capable of mobilizing the remaining deposits. Monitoring should continue until a determination is made that the majority of the sediment once stored behind the dams has been transported away from the dam sites and is no longer causing significant channel changes either downstream or upstream of the site of the former dam (although naturally occurring high flow events will continue to drive channel changes).

Channel planform and surface mapping

- Low elevation aerial photography of the reservoir deposit and potentially affected upstream and downstream channel reaches should be taken prior to dam removal to provide a record of baseline planform characteristics and the distribution of bed surface facies. The survey should occur following construction of pilot channels prior to dam removal. The low elevation photography, taken from a helicopter or using a balloon camera, should be corrected based on survey of ground control points and combined into a spatially accurate mosaic of the potentially affected channel reaches. Potentially responsive areas should then be identified by combining aerial photography and field reconnaissance mapping of channel morphology, within-reach sediment sources, existing sediment storage reservoirs, wetted channel width, and high flow channel connectivity. Potentially responsive sites are those areas where aggradation and degradation are most likely to occur in response to reservoir sediment release and may include pools, channel segments with alluvial morphology, major gravel/cobble bars forced by planform curvature or large roughness elements, and floodplain depositional surfaces. These are the sites that warrant detailed investigation following dam removal. Low elevation aerial photography should be repeated immediately following dam removal and following the first storm season to document changes in channel planform and facies composition.

Bed sediment volume and particle size surveys

- Bed surface facies composition should be mapped in the field onto the spatially corrected photographic mosaic. The facies mapping can then be used to 1) determine where textural changes have occurred in response to the sediment pulse, 2) quantify the areal extent of facies changes, and 3) identify where pebble counts and bulk sediment samples should be collected.
- Pebble counts and bulk samples should be collected from the reservoir deposits and from responsive sites in downstream channel reaches to calibrate facies mapping and quantify changes in subsurface grain size distribution.
- Sediment grab samples should also be collected from the surface of pool margins to characterize the particle size distribution of sediment filling pools.
- Sampling of the extent of potentially suitable spawning habitat locations and gravel permeability in potential spawning areas will be conducted as part of the habitat-biology monitoring components of this project, and compared to pre-dam removal surveys. Analysis of rearing and holding habitat is not encompassed under this monitoring plan.

Channel elevation surveys

- A thalweg longitudinal profile should be surveyed from the upstream limit of potentially affected channel upstream of the reservoir deposit to the downstream limit of potentially affected channel downstream of the dam site.
- Within the limits of the thalweg survey, cross-sections should be surveyed at periodic intervals. Where appropriate, the 27 cross sections surveyed as part of the sediment impact analysis conducted by the U.S. Department of Interior Bureau of Reclamation (Greimann 2001b) should be reoccupied along with any other previously monumented sections (e.g. from IFIM analysis) for sediment monitoring and be supplemented by other sections in strategic locations. Sediment depth should be measured across each cross section (if fine enough to probe).
- The dynamics of scour and fill of gravel bars in the vicinity of cross sections should be measured using scour chains and/or scour cores, while the volume of sediment infilling of pools should also be quantified by measuring the thickness of fine sediment mantling the armored pool bed, similar to the methods described by Hilton and Lisle (1993) and the Sierra National Forest (USFS 1997).
- Detailed total station topographic surveys of the bed surface should be conducted at the potentially responsive sites identified using the low elevation aerial photography. Topographic surveys should commence prior to dam removal, be repeated immediately following dam removal and then again following bed-mobilizing floods during the first year after dam removal. If dam removal is followed by a dry year, topographic surveys need only be repeated at the end of the winter storm season. Topographic surfaces can then be used to calculate bed elevation and volume changes over time. After the first year, periodic topographic surveys should be conducted following bed-mobilizing flows until such time that the impact of the sediment pulse appears to be negligible.

Sediment transport and model effectiveness evaluation

- Data should be collected to establish sediment transport rating curves and to estimate average unit sediment discharge and sediment transport rate in the affected reaches in order to compare predicted and observed erosion and deposition rates, and judge the effectiveness of various modeling scenarios. However, direct measurement of sediment transport during flood events near the dam removal sites will be difficult due to challenging access and potential safety considerations. It is proposed that sediment data collection concentrates on establishing reliable stage-discharge and sediment rating curves for established gauges. As such:
  - Flow velocity and depth should be measured at regular, closely-spaced intervals across each gauge site section over range of high flows to extend the range of reliable stage-discharge records available at these gauges;
  - Bedload samples and depth integrated suspended sediment samples should be collected during each high flow sampling episode as the basis for constructing sediment rating curves for each gauge. Installing suspended sediment sensors may be an advisable means of extending the suspended sediment records beyond the high flows if warranted by hypotheses related to habitat.

Monitoring Tasks

This monitoring plan assumes that Wildcat Diversion Dam will be removed in September 2005, South Diversion Dam in October 2007, and Coleman Diversion Dam in late summer of 2008. Each dam removal will occur when summer baseflows are insufficient to mobilize stored coarse sediment. Baseline conditions will be established prior to dam removal and all subsequent surveys will be compared to baseline conditions established prior to dam removal. The need for surveys immediately following dam removal will be determined at the time of dam removal based on the amount of sediment initially released from reservoir deposits to downstream reaches. Storm season monitoring will begin during the first event capable of mobilizing the reservoir deposit.

This plan assumes that three Study Reaches will be established prior to dam removal: the South Diversion Dam Reach (970 m long [0.6 mi.]), Coleman Diversion Dam Reach (1290 m long [0.8 mi.]), and Wildcat Diversion Dam Reach (970 m long[0.6 mi.]). Approximate Study Reach lengths assumed in this plan were conservatively estimated from the upstream and downstream extent of bed elevation changes observed in USBR modeling of bed profile changes in response to dam removal (Greimann 2001b). This plan assumes that channel cross sections will be established approximately 150 m apart throughout each reach. The actual length of study reaches and number of cross sections will be determined based on information obtained in task 1 and field reconnaissance during Task 3.

Pre-Removal Surveys and Monitoring
Total estimated cost: $220,618

Task 1. Compile relevant information
Estimated cost: $1,540

The first task will be to acquire existing gaging records, sediment sampling and survey data from the USBR sediment impact analysis, cross section survey data from the PHABSIM study, habitat mapping, topographic maps, and available aerial photography. A brief review of available literature and historical records will be conducted to identify important geomorphic processes and the chronology of episodic events controlling sediment production and transport in the basin (e.g., fire, flood events, and anthropogenic influences). Available mapping and aerial photography will be used to identify 1) the probable upstream, downstream, and valley width extent of potential channel response following removal of South Diversion, Coleman, and Wildcat dams; 2) preliminary long-term study sites for measuring cross section morphology, discharge, and sediment flux; and 3) logistics for reconnaissance and baseline conditions surveys.

Task 2. Create low elevation aerial photographic mosaic of baseline conditions prior to dam removal
Estimated cost: $67,161

Low elevation aerial photography will be conducted with a digital camera suspended from a tethered helium balloon. Photography will be taken from no more that 250 feet above the valley bottom and will image both the full extent of reservoir deposits and potentially responsive downstream channel reaches. A potentially response reach is defined here as the downstream channel bed, banks, and floodplain that may experience measurable bed elevation changes in response to sediment released by dam removal. Initial digital photographs will be downloaded in the field and printed for use during a survey of control points. At least 4 control points will be surveyed per photograph with a total station. Finally, a geographic information system (GIS) will be used to create a spatially correct mosaic and to tile the mosaic into 11x17 sheets of known scale for use in field mapping.

Task 3. Field reconnaissance of potentially responsive channel reaches
Estimated cost: $22,575

A field reconnaissance will be conducted to map channel morphology in study reaches using a process-based classification system (e.g., Montgomery and Buffington 1997; Wohl 1998) and to identify other important channel features such as pools, within-reach sediment sources, and sediment storage reservoirs. Information from the field reconnaissance will be used to assess the upstream, downstream, and valley width extent of monitoring reaches and to select suitable sites for monitoring morphological changes (i.e., topographic and cross section surveys), discharge and sediment flux (i.e., bedload traps and suspended and bedload sampling), scour and fill (i.e., scour chains and cores,), pool filling (i.e., V*), and particle size changes (i.e., facies mapping, pebble counts, and bulk sediment sampling).

Task 4. Baseline facies mapping
Estimated cost: $16,404

Bed-surface facies will be delineated onto the photographic base map of each study reach created during Task 2. Facies represent relatively homogeneous textural patches delineated based on surface grain size distribution. Textural patches reflect relative sediment supply rate and bedload transport processes, and therefore, provide a natural template for stratifying sediment sample sites (Buffington and Montgomery 1999a, 1999b). Sediment facies will be assigned dominant and subdominant particle size classes, with subdominant facies comprising 10% or more of the bed surface area. Site-specific and reach-wide comparisons will be made with baseline conditions to assess changes in patch area and texture following sediment release. Results of the facies mapping will be shown on the low elevation photography and tabulated by area of dominant and first subdominant facies.

Task 5. Baseline thalweg, cross section, and pool surveys
Estimated cost: $27,071

A thalweg longitudinal profile of each study reach will be surveyed prior to dam removal. Cross-sections will be surveyed at periodic intervals (approximately 150 m) within the limits of the thalweg survey. Where appropriate, cross sections surveyed as part of the sediment impact analysis (Greimann 2001b), the IFIM study (Payne and Associates 1998), and USGS or PG&E gaging efforts will be reoccupied. Appropriate cross sections are defined here as those that minimize variability in velocity, depth, slope, grain size, and τ_0. Sediment depth will be measured across each section (if fine enough to probe) and the volume of mobile fine sediment mantling the bed of wadeable pools within the reach will be measured using V* or an equivalent method.

Task 6. Baseline topographic surveys at potentially responsive sites
Estimated cost: $36,814

Site-specific topographic surveys will be conducted with a total station at reservoir deposits and at potentially responsive sites in downstream channel reaches. Surveys will consist of closely-spaced x, y, and z point densities that vary depending on the size of the site and the topographic variability. The goals of the initial site-specific topographic surveys are to 1) describe sediment volume changes in reservoir deposits, and 2) describe bedform changes at potentially responsive sites (e.g., sediment storage reservoirs in the lee of obstructions, at bends, and in lower gradient reaches) within each study reach. Topographic survey data at a site will be converted to a surface using a triangulated irregular network, and baseline surfaces will be compared with surfaces following dam removal to calculate bed elevation and volume changes in response to dam removal and sediment release.

Task 7. Baseline sediment sampling at potentially responsive sites
Estimated cost: $24,310

Limited sediment sampling will be conducted at potentially responsive sites in order to compare baseline grain size distribution with grain size following sediment release. Surface grain size distribution will be characterized with pebble counts from alluvial facies throughout the reach using the methods described by Wolman (1954). Pebble count results will be displayed on the facies maps. Subsurface grain size distribution will be characterized with volumetric bulk sediment samples using McNeil or similar pipe or barrel samplers. Bulk sampling will occur at only a limited number of sites with high existing aquatic habitat value and where fine sediment impacts are a particular concern. The number and location of pebble counts and bulks samples will be determined during facies mapping. All sediment sampling will be conducted at wadeable flows.

Task 8. Install scour chains, scour cores, and bedload traps
Estimated cost: $24,742

An array of scour chains, scour cores, and bedload traps (pit and /or net traps) will be installed to monitor scour, fill, and transport of gravel during the first storm season. Scour cores and chains will be used in combination with the topographic surveys to document changes in bed elevation. Annual bedload transport over the first storm season will be measured using bedload traps. Bedload traps (pit or net trap) will be installed in the vicinity of at least one long-term cross section (established during Task 6) in each reach where equipment can access the channel. Installation of scour chains, score cores, and bedload traps will occur immediately following dam removal and initial sediment release. If dams are removed during the storm season or spring runoff period when high flows may prohibit access, installation will occur prior to dam removal.

Year One Post-Dam Removal Monitoring and Reporting
Total estimated cost: $250,302

Task 9. Monitor water and sediment discharge during the first storm season
Estimated cost: $25,982

Sampling of flow and sediment discharge will occur over a range of flows during the first storm season and subsequent spring runoff period. Sampling will occur during approximately 5 moderate storm events. During each sampling event, discharge and average velocity will be calculated from closely-spaced depth and velocity measurements at one or more cross-sections in each reach. A velocity profile will also be measured at each of these cross sections. The discharge and velocity data will be used to calibrate flow at ungaged cross sections to established gaging stations in the basin.

Sediment transport over the first storm season will be measured using bedload traps (pit or net traps), Helley-Smith bedload samplers and USGS suspended sediment samplers. The Helley-Smith sampler will be used to measure bedload transport of grains <10 mm at bridge locations near established gauges, while bedload traps will measure transport of coarse bedload (>10 mm) at long-term cross-sections where equipment can access the channel. Helley-Smith bedload samples and depth-integrated suspended sediment samples will be taken across the channel at closely spaced intervals (~ 2 m spacing at <5 min intervals) during each discharge sampling. Sediment samples will be dried, sieved, and weighed. Flow and sediment data from each sampling will be used to establish stage-discharge relationships and sediment rating curves at sampling sites. Bedload transport measurements will be used to calibrate transport formulae, thereby increasing the accuracy of the predictive transport model. This calibrated approach has been shown to optimize accuracy and cost (Wilcock 2001).

Task 10. Geomorphic monitoring following the first storm season
Estimated cost: $202,059

Geomorphic monitoring will be conducted immediately following the first storm season to document changes in response to reservoir sediment release. Monitoring methods will be identical to those described in Task 2 and Tasks 4-8, including 1) creating a low elevation aerial photographic mosaic of conditions following the first storm season; 2) facies mapping; 3) surveys of channel thalweg profile, cross sections, and pools; and 4) topographic surveys at responsive sites. Scour chains, scour cores, and bedload traps will be reset or re-installed (where necessary) in preparation for the second season of monitoring.

The results of geomorphic monitoring following the first storm season will serve as a description of initial conditions at the beginning of the second storm season. The upstream, downstream, and valley width extent of sediment monitoring reaches during the second season may expand or contract depending on observed changes in bed elevation and texture during the first season. Sites for monitoring morphological and textural changes during the second season may be adapted based on changes observed following the first season.

Task 11. Conduct sediment transport modeling of channel recovery during the first storm season
Estimated cost: $8,619

Sediment size fractions and transport functions to be used in modeling total bedload transport rate and transport rate of individual size fractions will first be specified. Transport functions will then be calibrated to the sampled bedload transport rates. Sediment rating curves for separate size fractions will then be developed and numerical simulations of cross-sectionally averaged bedload transport rate, bed elevation, and both surface and bedload mean grain size will be conducted. From these results, the form, centroid, and composition of the sediment pulse will be evaluated. Numerical simulations will be compared to results of the first-year geomorphic monitoring to evaluate model effectiveness.

Task 12. Prepare first-year monitoring report
Estimated cost: $13,642

A technical report will be prepared that summarizes the first year of geomorphic monitoring methods, analyses, results, and conclusions. The report will include aerial photographs; channel long profile and cross-section surveys; topographic surveys; summary tables of sediment sampling, sediment transport, and flow data; rating curves; and results from sediment transport modeling.

Year Two Post-Dam Removal Monitoring and Reporting
Total estimated cost: $250,302

Task 13. Monitor water and sediment discharge during the second storm season
Estimated cost: $25,982

Sampling of flow and sediment discharge will occur over a range of flows during the second storm season and subsequent spring runoff period. The methods, sample sites, and sampling intervals will be identical to those outlined in Task 9 for monitoring during the first storm season. Flow and sediment data from each sampling during the second storm season will be used to refine stage-discharge relationships and sediment rating curves established during the first storm season.

Task 14. Geomorphic monitoring following the second storm season
Estimated cost: $202,059

Geomorphic monitoring will be conducted immediately following the second high-flow season to document changes in response to reservoir sediment release. Monitoring methods will be identical to those described in Task 2 and Tasks 4-8, including 1) creating a low elevation aerial photographic mosaic of conditions following the second storm season; 2) facies mapping; 3) surveys of channel thalweg profile, cross sections, and pools; and 4) topographic surveys at responsive sites.

Task 15. Conduct sediment transport modeling of channel recovery during the second storm season
Estimated cost: $8,619

Modeling methods will be identical to those described in Task 11. In addition, comparisons will be made between first and second year channel conditions, and predictions will be made of the form and composition of the sediment pulse during third and fourth years.

Task 16. Prepare second-year monitoring report
Estimated cost: $13,642

A technical report will be prepared that summarizes the second year of geomorphic monitoring. The report will include aerial photographs; channel long profile and cross-section surveys; topographic surveys; summary tables of sediment sampling data, sediment transport, and flow data; rating curves; and results from sediment transport modeling. The second-year monitoring report will provide interpretations of predicted channel recovery based on synthesis of first- and second-year empirical and model results. The report will also evaluate the validity of the conceptual model, test the hypotheses presented on page 10 of this plan, and assess the utility of the methods for monitoring future dam removal in similar settings.

Prospect of adaptive management actions

The nature of the sediment monitoring task and the relatively small volume of coarse material stored behind the dams means that the prospect of passively adaptive actions being required in this task is minimal. Instances in which remedial actions may be required include:

- Surveying evidence indicates a significant threat to infrastructure as a function of the morphological evolution of the river following dam removal (e.g. threat to county road bridge downstream of South Diversion) Corrective actions may involve excavation of accumulated sediment;
- Surveying evidence indicates a significant volume of fine sediment accumulating in pools which, due to the volume of fine sediment still to be released from upstream, could be a long-term effect with negative habitat implications. Corrective actions may involve vacuum removal of accumulated fine sediment.
- Surveying evidence indicates significant fish passage impediments in the former reservoir site due to the routing of baseflow around large sediments. Corrective actions may involve rearrangement of the sediments, or reducing their effect using other sediment if the material is too large to maneuver.

References

Borcalli, F., Gathard, D., Gregory, S., Rondorf, D., Stensby, D., and E. Wohl. 2003. Technical Review Panel Report, Battle Creek Salmon and Steelhead Restoration Project. September. 32 p.

Buffington, J. M., and D. R. Montgomery. 1999a. A procedure for classifying textural facies in gravel-bed Rivers. Water Resources Research, 35(6): p. 1903-1914.

Buffington, J. M., and D. R. Montgomery. 1999b. Effects of sediment supply on surface textures of gravel-bed rivers. Water Resources Research, 35(11): p. 3523-3530.

Cui, Y., G. Parker, T. E. Lisle, J. Gott, M. E. Hansler-Ball, J. Pizzuto, N. E. Allmendinger, and J. M. Reed. 2003a. Sediment pulses in mountain rivers: 1. Experiments. Water Resources Research 39(9): p. ESG 3-1 to ESG 3-12.

Cui, Y., G. Parker, J. Pizzuto, and T. E. Lisle. 2003b. Sediment pulses in mountain rivers: 2. Comparison between experiments and numerical predictions. Water Resources Research 39(9): p. ESG 4-1 to ESG 4-11.

Doyle, M.W., Stanley, E.H. and Harbor, J.M. 2002. Geomorphic analogies for assessing probable channel response to dam removal. Journal of the American Water Resources Association, 38: 1567-1579.

Doyle, M. W., Stanley, E. H., and J. M. Harbor. 2003. Channel adjustments following two dam removals in Wisconsin. Water Resources Research, 39(1).

Greimann, B.P. 2001a. Hydrology of North Fork and South Fork Battle Creeks: Battle Creek Salmon and Steelhead Restoration Project, California. Prepared by USBR Technical Service Center. April.

Greimann, B.P. 2001b. Sediment Impact Analysis of the Removal of Coleman, South, and Wildcat Diversion Dams on South and North Fork Battle Creeks: Battle Creek Salmon and Steelhead Restoration Project, California. Prepared by USBR Technical Service Center. April. 33 p.

Hilton, S. and Lisle, T. E. 1993. Measuring the fraction of pool volume filled with fine sediment. USDA Forest Service, Pacific Southwest Research Station, Berkeley, California. July. Research Note PSW-RN-414.

Jones and Stokes. 2003. Battle Creek Salmon and Steelhead Restoration Project Draft Environmental Impact Statement/Environmental Impact Report. July 2003.

Kier Associates. 2001b. Draft Battle Creek Salmon and Steelhead Restoration Project Adaptive Management Plan, Appendix D. September.

Lisle, T. E., J. E. Pizzuto, H. Ikeda, F. Iseya, and Y. Kodama. 1997. Evolution of a sediment wave in an experimental channel. Water Resources Research 33(8): p. 1971-1981.

Lisle, T. E., Cui, Y., Parker, G., Pizzuto, J. E., and A. M. Dodd. 2001. The dominance of dispersion in the evolution of bed material waves in gravel-bed rivers. Earth Surface Processes and Landforms 26: 1409-1420.

Montgomery, D. R., and J. M. Buffington. 1997. Channel-reach morphology in mountain drainage basins. Geological Society of America Bulletin 109(5): p. 596-611.

Payne and Associates. 1998. Battle Creek fisheries studies, Task 1: Instream flow study. Prepared for the California Department of Fish and Game. April 27.

Pizzuto, J. 2002. Effects of Dam Removal on River Form and Process. Bioscience 52 (8): 683-691. August.

Stillwater Sciences. 2002. Dam Removal Express Assessment Models (DREAM), Technical Report, October.

Wilcock, P. R. 2001. Toward a practical method for estimating sediment-transport rates in gravel-bed rivers. Earth Surface Processes and Landforms 26: p. 1395-1408.

Wohl, E. E. 1998 Bedrock channel morphology in relation to erosional processes. In Rivers over rock: Fluvial processes in bedrock channels. Geophysical Monograph 107, Tinkles, K. J., and E. E. Wohl. Editors.

Wolman, G. M. 1954. A method of sampling coarse river-bed material. Transactions of the American Geophysical Union 35: 951-956.

Wooster, J., 2002. Geomorphic responses following dam removal: a flume study. Unpublished M.S. Thesis, University of California, Davis.

VII. FOCUSED STUDY: RIPARIAN HABITAT MONITORING

DATE: March, 2004

FROM: Mike Roberts, Bart Prose, Sheila Byrne, Bob Williams, Craig Martz, and Harry Rectenwald

SUBJECT: Battle Creek Adaptive Management Riparian Monitoring Plan: draft

Background

The U.S. Department of the Interior Bureau of Reclamation and the California State Water Resources Control Board have submitted the Battle Creek Salmon and Steelhead Restoration Project (Restoration Project). The Restoration Project has the goal of restoring and enhancing about 42 miles of anadromous fish habitat in Battle Creek and an additional 6 miles of habitat on its tributaries, while minimizing the loss of renewable energy produced by the Battle Creek Hydroelectric Project (Federal Energy Regulatory Commission Project No. 1121). The Restoration Project preferred alternative as described in the EIR/EIS involves removal of five dams and appurtenant facilities, installation of fish screens and ladders on three dams, installation of stream gages, and increases to minimum instream flows (Jones & Stokes 2003).

The Restoration Project includes an important adaptive management component to monitor the effectiveness of restoration actions and make additional adjustments to the Hydroelectric Project facilities and/or operations as needed (Kier Associates 2001). A Technical Review Panel (Panel), formed by the CALFED Bay-Delta Program, provided a comprehensive evaluation of the Restoration Project preferred alternative as described in the EIR/EIS. The Panel recommended increased emphasis on monitoring in the Battle Creek Restoration Project in order to: "1) identify deficiencies or critical actions for adaptive management; 2) document the degree of success of the project; or 3) identify key responses or relationships for planning and implementing similar projects throughout the region" (Borcalli et al. 2003, p. 21).

The Panel noted that costs to fund revegetation activities, as mitigation for habitat losses during construction activity, seemed excessive. Revegetation costs for mitigation of a variety of habitats range from 4 to 14 million dollars. Although this cost range includes mitigation actions for other vegetation communities, construction activities are projected to impact a conservative total of 7.2 acres of riparian forest/scrub habitat. The Adaptive Management Technical Team (AMTT) assumed that project restoration actions would result in direct benefits to riparian forest/scrub habitat.

The AMTT thought an ecosystem-wide context could be applied for compensation of project impacts, consistent with the CALFED Ecosystem Restoration Program (ERP) as a whole and recognized within the peer reviewed literature (Gregory et al. 1991), and that these benefits could be quantified to serve as partial credit towards mitigation of this habitat type. For example, construction activities are projected to impact 7.2 acres of riparian forest/scrub habitat. In a conversation between Bureau of Reclamation, NOAA Fisheries, USFWS, Department of Fish and Game (DFG), Pacific Gas and Electric Company (PG&E), and Metropolitan Water District, the participants decided that a compensation ratio for riparian forest/scrub would be reduced from 5:1 to 3:1, given that supporting criteria could be met. Following the AMTT's suggested approach, the project could be considered partially "self-mitigating" regarding the riparian forest/scrub community if benefits to this habitat resulting from the increased stream flows of the project included an increase in acreage and/or quality. Although there is scientific uncertainty, these responses may occur on Battle Creek and are supported in the literature. Therefore, in addition to the expected benefits to riparian vegetation from increased instream flow, 21.6 acres of habitat compensation would be required to fully offset mitigation requirements for riparian forest/scrub.

Other actions are also under consideration that would inform a self mitigation perspective for this and other habitat types. Substantial conservation easements exist within the watershed and provide protection for a number of habitat types. These two approaches combined should result in significant mitigation related cost savings to the restoration project. The AMTT also recognizes the learning value of a riparian monitoring component within the project. This monitoring serves to quantify benefits of the project not only to the targeted salmonid species but also approaches an ecosystem-wide perspective.

Monitoring Goals

This report identifies a draft monitoring program to document potential benefits to riparian habitats hypothesized to result from increases in streamflow, a primary aspect of the Battle Creek Salmon and Steelhead Restoration Project. The AMTT's hypothesis is that pre-project summer baseflows (~5 cfs) are a limiting factor (Auble et al. 1994, Stromberg and Patten 1991) to the spatial extent (including connectivity), diversity (species and age class structure), and vigor (growth rate) of riparian forest/scrub habitats. Baseflow is likely to be a limiting factor in the less geomorphically constrained and more alluvial reaches along Battle Creek. We hypothesize that an increase in summer baseflows will benefit these habitats and that changes will be detectable through 1) repeat aerial photography mapping, 2) Field based habitat monitoring, and 3) Growth increment coring analysis. The justification and approach for these three study components are discussed later in the report.

This monitoring program is considered draft for a number of reasons. Most importantly, time constraints in the formulation of AMTT responses to panel comments did not allow for extensive discussion with riparian habitat experts nor a field tour to familiarize workers with existing Battle Creek riparian conditions. Therefore, we utilized a riparian monitoring investigation from the Sacramento River title "The Distribution and Composition of Woody Species in Riparian Forests along the Middle Sacramento River, California" (Wood 2003) as a reference study for the field based monitoring approach. We recognizing that geomorphic and hydrologic conditions are very different between the two systems. However, standard forestry monitoring practices were utilized in the Wood (2003) study and should be transferable to the Battle Creek System in order to detect change in riparian habitats. This reference study is available for download at http://www.sacramentoriverportal.org/reports/beehive/apdx5.pdf.

The study is also considered draft due to the long response time (5 to 10 years) that the AMTT assumes it will take for significant riparian habitat response to increased baseflows. We are primarily seeking to characterize the baseline conditions of riparian habitat at this time. We assume that the same monitoring protocols used to characterize baseline conditions may be repeated at five and ten years, allowing comparison of habitat response over time. Based on that assumption, we include provisional cost estimates at this time for future monitoring. However, the CALFED ERP program is the likely funding source and ERP grants are limited in duration to three years. This limitation provides the opportunity for the AMTT to more thoroughly vet the study after baseline conditions are characterized to ensure that future monitoring activities are designed to detect hypothesized changes and to more accurately capture monitoring costs. At this time, the AMTT did not feel that current conditions placed a limitation on riparian regeneration processes, a common result of flow regime alteration. Therefore, we did not formulated a study component to investigate that aspect of riparian dynamics within the system.

Battle Creek Setting

The geomorphic and hydrologic conditions of a river system are intimately linked to riparian ecosystem dynamics. Therefore, a brief description of both physical conditions and riparian communities are included here. The following physical description is from the Stillwater Science Sediment Monitoring Plan (Stillwater 2004). Battle Creek drains approximately 357 mi^2 of the southern Cascade Range of the northern Central Valley and flows into the Sacramento River approximately 5 miles east of the town of Cottonwood. It has two main branches: North Fork Battle Creek (29.5 mi. long and drains 213 mi^2) and South Fork Battle Creek (28 mi. long and drains 124 mi^2) (Figure 1). The Battle Creek basin is predominantly comprised of young basalt flows overlain in places by interbedded lahar deposits, volcanic conglomerate, tuff, and pyroclastic debris of the Tuscan formation.

Battle Creek exhibits large spring-fed base flows due to thick snow accumulation at higher elevations and the highly permeable volcanic bedrock. Battle Creek has the largest dry-season base flow of the tributaries to the Sacramento River between Keswick Dam and the Feather River, with an average September flow of 255 cfs reaching the Sacramento River (Jones & Stokes 2003). South Fork Battle Creek is more likely to experience large peak flows from intense rainfall, while the North Fork Battle Creek receives a greater portion of its water at high elevation from snow-melt and spring-fed runoff, and is therefore, less variable (Jones & Stokes 2003) (Figure 2).

Overall gradient of North Fork Battle Creek is approximately 0.0300, while overall gradient of the South Fork Battle Creek is approximately 0.0200 (Figure 3). The region upstream of South Fork Diversion Dam is steep with a slope greater than 0.0300. Channel morphology is typically characterized by cobble-boulder cascades and by alternating pools and riffles that repeat every 5–7 channel widths. Periodic bars store significant amounts of coarse sediment. Sediment supply is heterogeneous, ranging from sand to boulders but with little silt or clay (Figures 4 and 5).

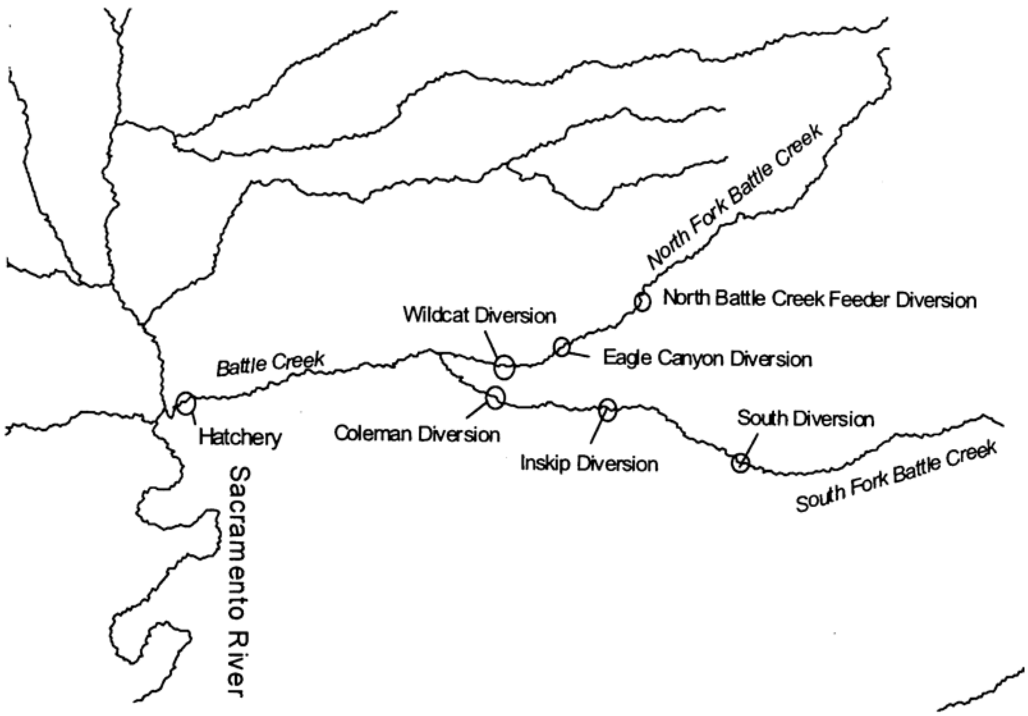


Figure 1. Map showing approximate location of diversion dams. Modified from Greimann 2001b.

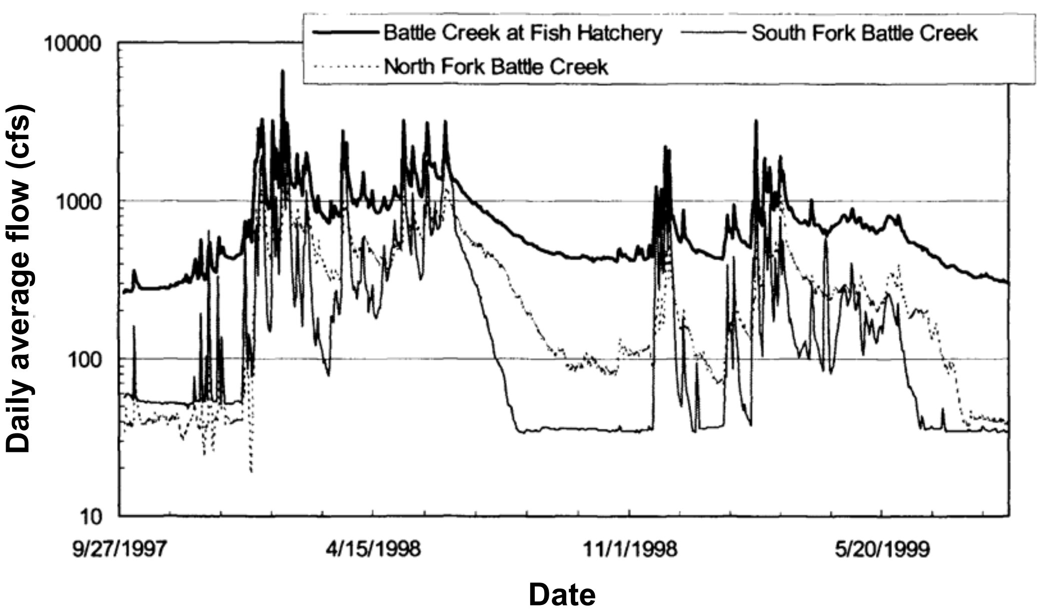


Figure 2. Daily average stream flows over the period of record for the North and South Fork stream gages as compared to the USGS gage. The flows were not corrected for diversions. Modified from Greimann 2001a.

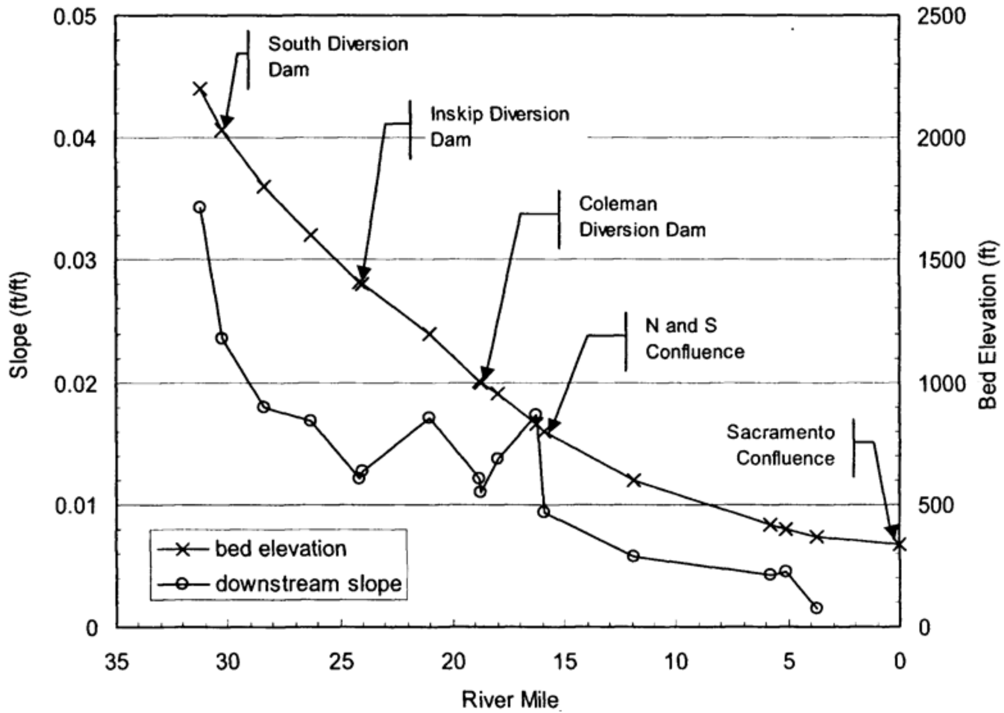


Figure 3. Bed profile of South Battle and Battle Creeks. Modified from Greimann 2001b.

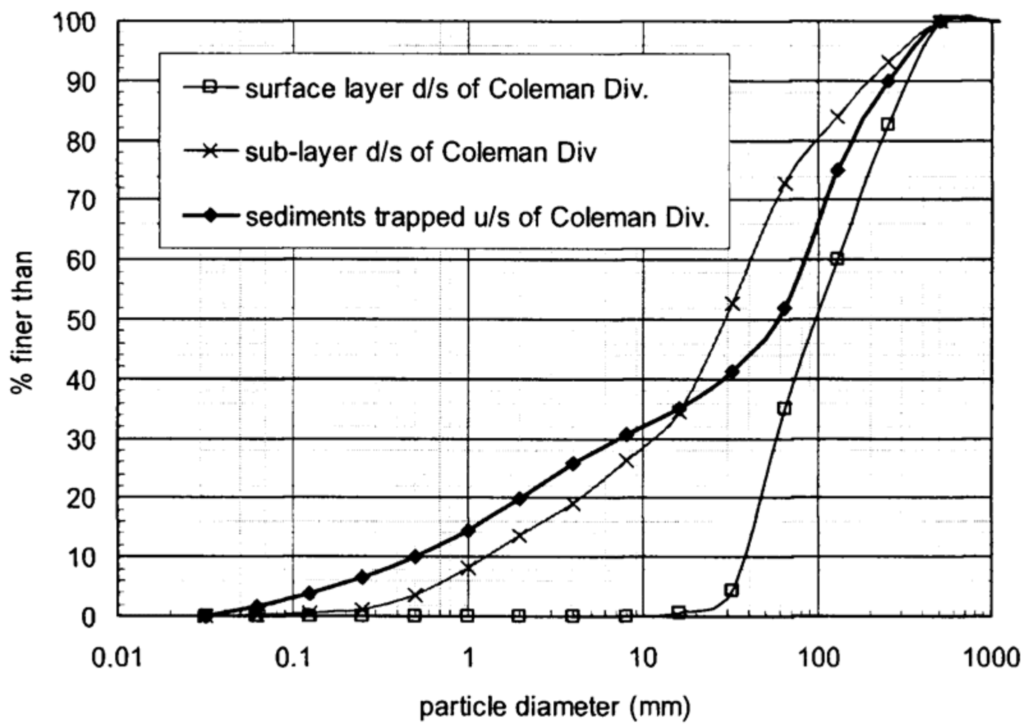


Figure 4. Sediment size gradations near Coleman Diversion Dam. Modified from Greimann 2001b.

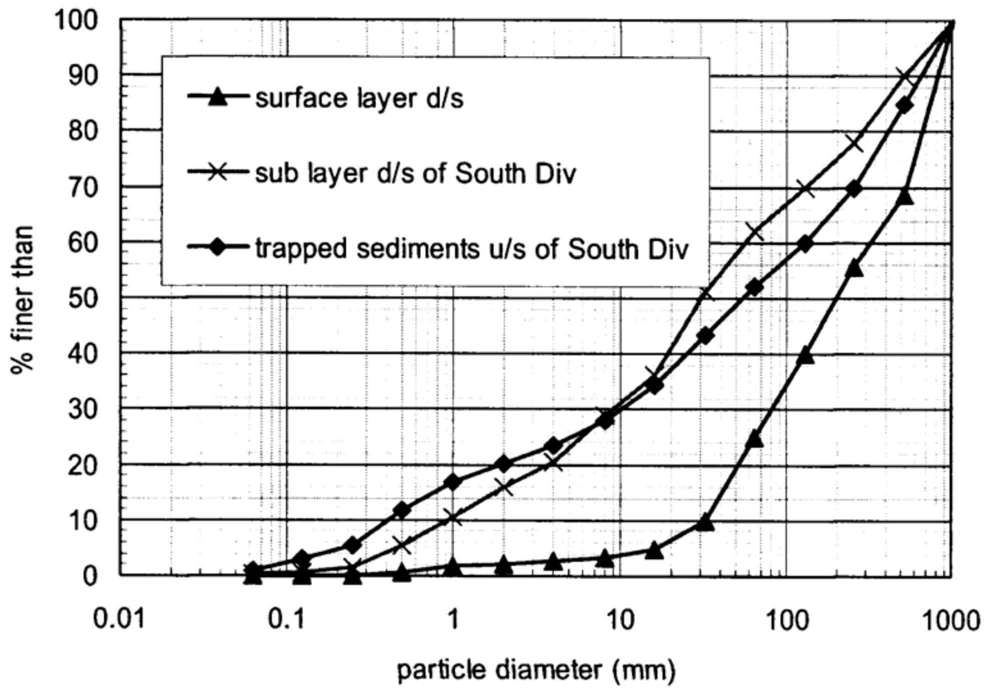


Figure 5. Sediment size gradations near South Diversion Dam. Modified from Greimann 2001b.

Plant communities and associated wildlife habitats are described in Chapter 4 of the Draft EIR/EIS (Jones & Stokes 2003). Areas projected as impacted by construction activities were mapped in detail for the Draft EIR/EIS and the following is a description of the riparian forest/scrub community and associated wildlife from the document.

> Riparian forest and scrub communities occur along perennial drainages in the Restoration Project area. For example, they occur along North Fork and South Fork Battle Creek, Ripley Creek, and Soap Creek; along several unnamed drainages; and in several emergent wetlands (Figures 4.2-3, 4.2-5, 4.2-7, 4.2-9, 4.2-11, 4.2-13, 4.2-15, 4.2-17 and 4.2-19; see also Table II-1 in Volume II of the Summary Report [Jones & Stokes 2001c] for a list of individual drainages that support riparian forest and scrub). Riparian scrub dominates areas along channels in most creeks and forms a mosaic with riparian forest or live oak woodland.
>
> In areas with broader floodplains, riparian trees such as valley oak and western sycamore tend to dominate the overstory. Patches of Himalayan blackberry, scattered willows, and California wild grape usually comprise the understory in these areas. In canyons with perennial streams (such as North Fork Battle Creek), several species are common in addition to the species listed above. Overstory species include California bay, white alder, big-leaf maple, fig, white mulberry, Douglas fir, Pacific yew, and Oregon ash. Understory shrubs include poison-oak, western spicebush, dogwood, and several species of willow.
>
> In the Restoration Project area, riparian communities are generally dominated by hydrophytic vegetation and hydrologic conditions, but lack hydric soil indicators.

> These riparian communities do not meet the Corps' definition of wetlands for purposes of the Clean Water Act because they lack all three indicators. Riparian communities that occur within the ordinary high water mark of Battle Creek and other drainages would be considered other waters of the United States, subject to regulation by the Corps under Section 404 of the Clean Water Act (33 USC 1251–1376).
>
> Riparian forest and scrub habitats are among the most important wildlife habitats in the Restoration Project area. These habitats attract a high diversity of resident and neotropical migratory birds; species observed during field visits included belted kingfisher, downy woodpecker, black phoebe, warbling vireo, orangecrowned warbler, bushtit, western scrub-jay, Bewick's wren, house wren, American robin, yellow-breasted chat, western tanager, black-headed grosbeak, lazuli bunting, spotted towhee, and song sparrow. Important seed-eating species included house finch and lesser goldfinch.
>
> Other representative wildlife species in riparian habitats of the Restoration Project area include most mammals, amphibians, and reptiles that are attracted by a source of flowing water. Riparian corridors are important deer migratory habitat. Bats may forage for insects over riparian areas in the canyons and roost in trees. The number of bat species using the Restoration Project area was not determined during the field surveys. Although not confirmed during field surveys, spotted bat, western red bat, fringed myotis, long-eared myotis, smallfooted myotis, long-legged myotis, Yuma myotis, pallid bat, and Townsend's big-eared bat potentially occur, and all are considered species of concern by USFWS.

Although some general vegetation mapping exists for the area from CAL-VEG (Figure 6), vegetation mapping is not available for Battle Creek beyond the construction footprint areas and the lower reach near the confluence with the Sacramento River (Figure 7). Baseline mapping will have to be created as a part of this monitoring program.

Study Approach

Researchers have shown riparian species compositions to shift towards more xeric species and become more limited in extent with decreasing baseflows (Stromberg et al. 1996). In addition, research suggests that riparian vegetation is especially sensitive to minimum and maximum instream flows (Auble et al. 1994). Although maximum instream flows occurring in Battle Creek would not be affected by the Restoration Project, minimum flows, which would occur during the primary growing season of riparian vegetation, would be increased up to 10 times, depending on location. A decrease in riparian vegetation resulting from a decrease in baseflow is a more likely response within an alluvial, unconfined floodplain and where a stream can be characterized as a losing reach. Riparian communities in these settings are probably most directly dependent on instream flows and less dependent on other sources.

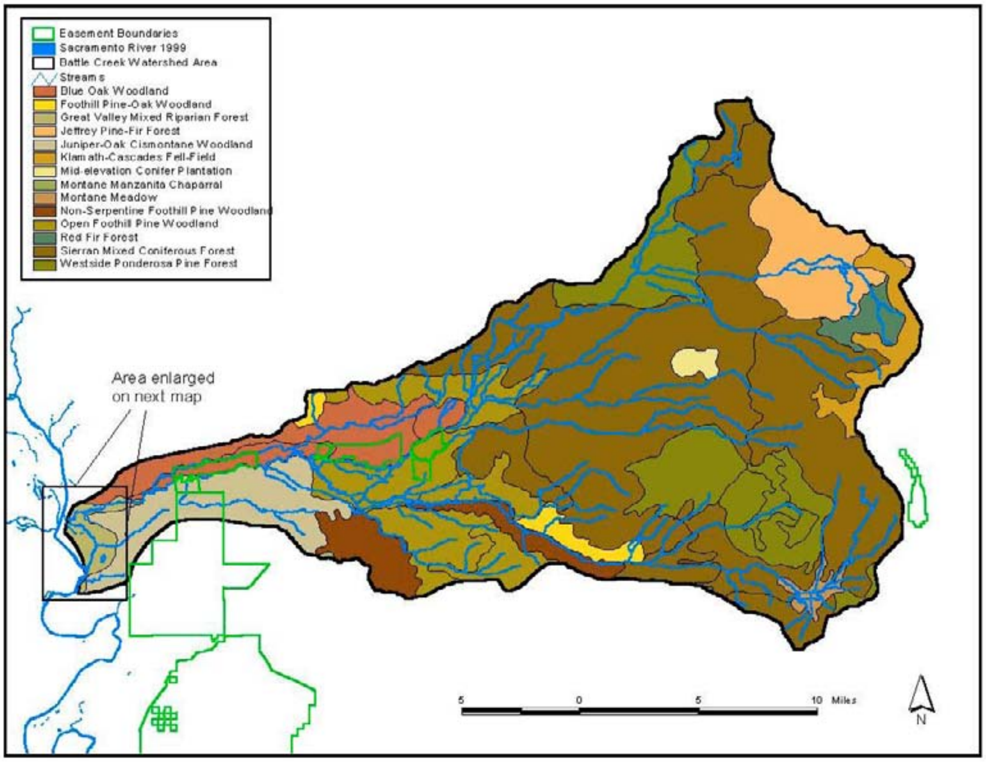


Figure 6. Vegetation community mapping from CALVEG for the Battle Creek watershed. The figure includes boundaries of current conservation easements purchased by The Nature Conservancy and funded by CALFED.

Increased minimum instream flows that are expected to re-establish and/or enhance riparian habitat would occur over a substantial spatial area due to the restoration project on Battle Creek. The linear extent of increased instream flows totals approximately 33 miles of the Creek, plus reaches of Soap Creek, lower Ripley Creek, and Baldwin Creek (reaches below uppermost diversion dams affected by Restoration Project). The reach of Battle Creek where increased baseflows are most likely to result in an increase in the spatial extent of riparian habitats is between the confluence of the North and South Forks and the Coleman Hatchery. Isolated reaches that are more alluvial in nature may exist upstream of the confluence, and overall connectivity of riparian habitats may improve.

The three monitoring components below will be used to quantify hypothesized benefits to riparian habitat resulting from increased stream flow.

Repeat aerial photography and vegetation mapping component

Hypothesis: Pre-project summer baseflows are limiting the spatial extent and connectivity that riparian forest/scrub is capable of occupying on the floodplain of Battle Creek. An increase in baseflow is hypothesized to result in an increase in available subsurface water within floodplain deposits, which will increase the area capable of supporting riparian vegetation. However, there is uncertainty that the Battle Creek riparian system will respond as described above. An increase in baseflows from 3-5 cfs to 35-40 cfs may not significantly alter river stage and corresponding groundwater conditions in alluvial reaches to the extent that "new" floodplain areas will become capable of supporting riparian vegetation.

Monitoring Goal: The goal of this study component is to quantify the distribution of plant communities as a function of increased streamflow over time. Although we expect vegetation to respond to increased streamflows within the less constrained and more alluvial geomorphic settings, we propose to map community type patches over a total of approximately 42 stream miles (Bart Prose, USFWS, personal communication 2004) that include downstream of North Battle Feeder Diversion Dam and South Diversion Dam on the North and South forks, respectively, and also on the reaches of Ripley and Soap Creeks that will experience increases in stream flow. This represents a total of and should be sufficient to detect improvements in connectivity. Vegetation communities will be mapped according to the CNPS classification system described by Sawyer and Keeler-Wolf on ortho-rectified aerial photography at a scale no larger than 1:7800. Figure 7 is an example of the detailed mapping necessary for the analysis.

These data are currently only available for the lower reach of Battle Creek. Aerial photo ortho-rectification and vegetation mapping would then be repeated 5 and 10 years after baseline characterization to detect the hypothesized response. Collection of aerial photography data may be combined with data collection for other studies for cost savings. For example, numerous data types including LIDAR, aerial photography, and thermal infrared, can be collected during a single flight and utilized by the riparian study and others such as the cold-water refuge study.

Field based monitoring component

Hypothesis: Habitat quality will improve as a result of increased baseflows. Aerial photography analysis will not yield data on finer resolution changes within the riparian communities and field monitoring will compliment these data. Numerous vegetation monitoring protocols are in use by researchers and practitioners (See: Platts et al., 1987, MacDonald et al., 1991). In the absence of time to review protocols and decide which is most appropriate for Battle Creek, we used methods outlined in the Wood (2003) study. Although specific habitat variables may change, the nature of the study is similar enough to facilitate extrapolation of techniques until further discussion with riparian ecologists and site visits can better inform a monitoring program.

Monitoring Goal: The goal of this study component is to inventory and characterize riparian community types, document species composition, and monitor for invasion of exotic species. We suggest that five indicator sites be selected as representative of overall system response. The Wood (2003) study applied standard forestry monitoring techniques and statistical analyses to characterize differences between sites. Similar techniques may also be suitable to characterize difference at a site over time. Our suggested methods are outlined below and taken from the Wood (2003) study.

> Within the plot the diameter of all trees or tree-like shrubs with stems > 2.5 cm dbh (diameter at breast height) was recorded. Stem diameters (cm) were converted to basal area (cm^2) using standard formulas for circles. Basal area is typically referred to as dominance, or ecological influence, by forest ecologists (Kimmins 1997).

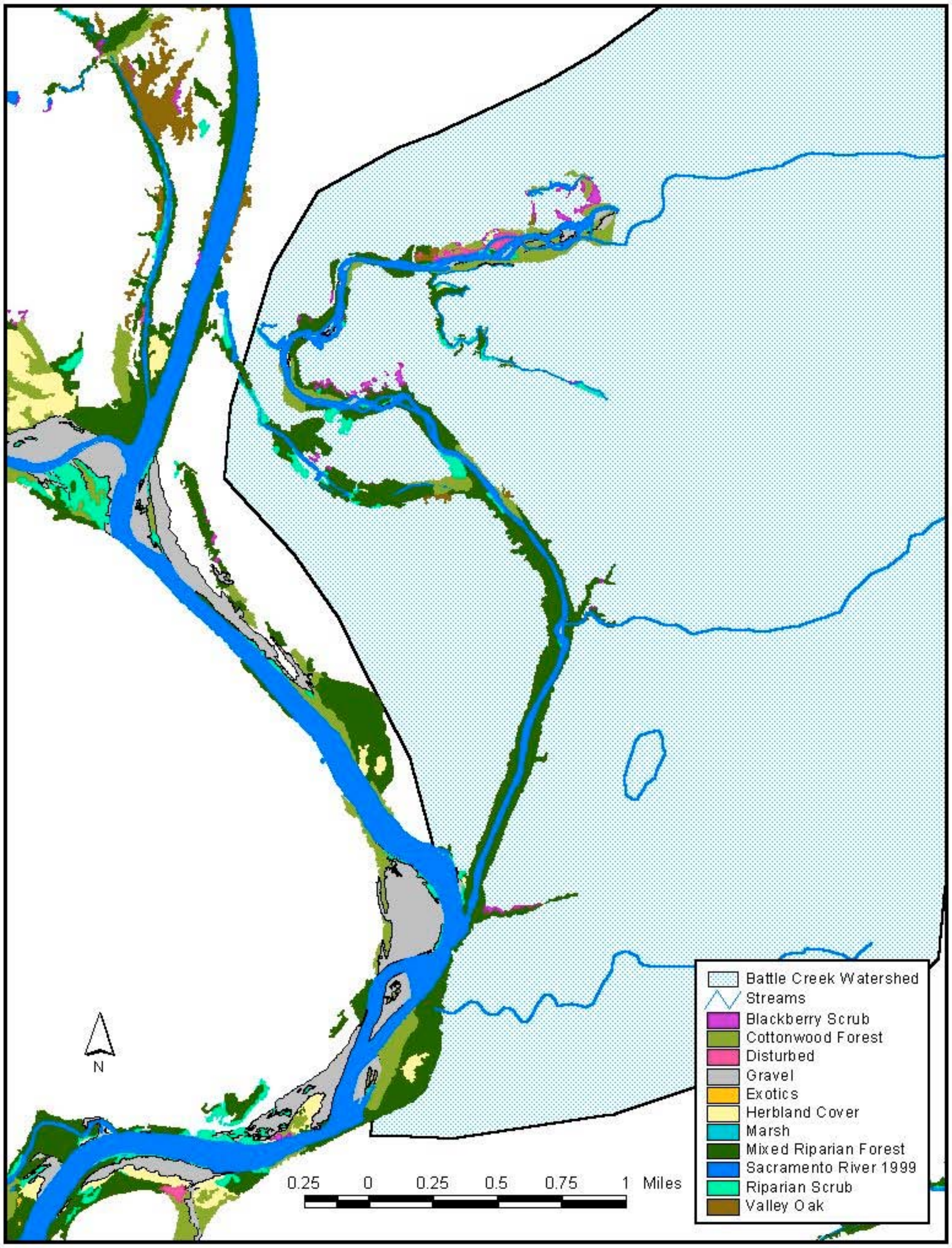


Figure 7. Vegetation communities mapped according to Sawyer and Keeler-Wolf along the mainstem Sacramento River and the lower reach of Battle Creek.

Importance values for all tree species in a plot were then calculated as the sum of relative density (each species' density divided by total density of all species) plus relative dominance (each species' basal area divided by total basal area of all species). Importance values thus reflect both the number and size of individual species. In this way, saplings can be compared along with mature trees.

Multivariate analyses were performed using the PCORD software version 4.2 (MjM software, Gleneden Beach, OR). Ordination was by detrended correspondence analysis, and cluster analysis used Euclidean distances and Ward's method of clustering.

The cover of all herbaceous species in a plot will be tallied according to the Daubenmire abundance scale (Barbour et al. 1999). A complete plant species list will be compiled and the presence of any large patches of nonnative invasive species such as giant reed (*Arundo donax)* or Himalayan blackberry (*Rubus discolor)* will be noted, should they not have been sampled already by the line transects.

Canopy cover will be estimated using a densiometer.

Figures 8, 9, and 10 are selected examples from the Wood (2003) study to represent the format of results from this proposed work.

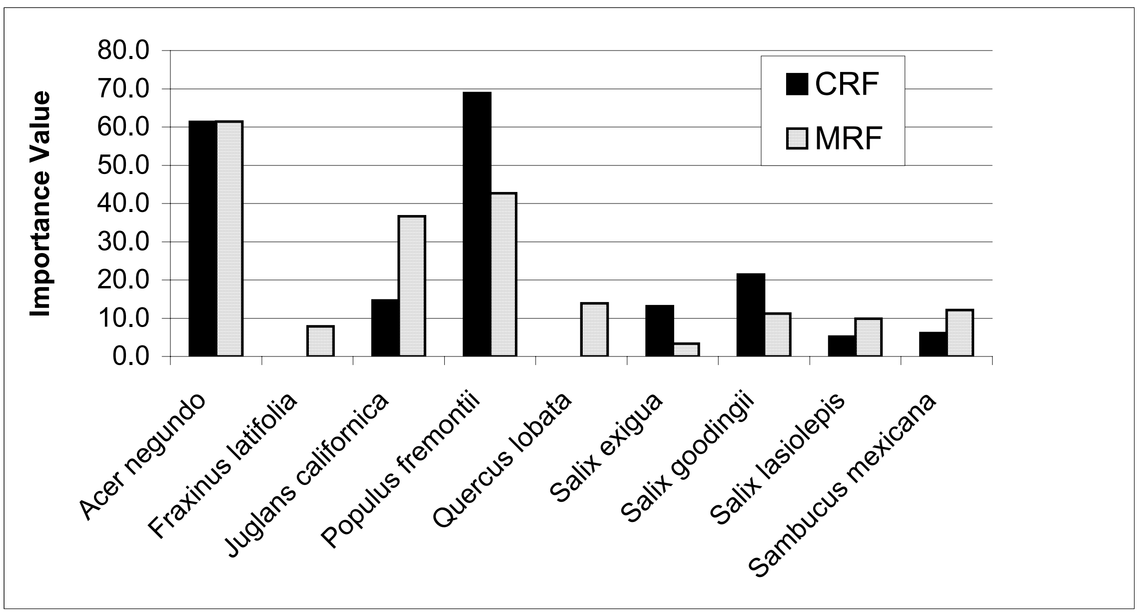


Figure 8. Comparison of mean importance values of common species in Fremont cottonwood riparian forest (CRF) versus mixed riparian forest (MRF). Importance values are calculated as the sum of relative density plus relative dominance (basal area).

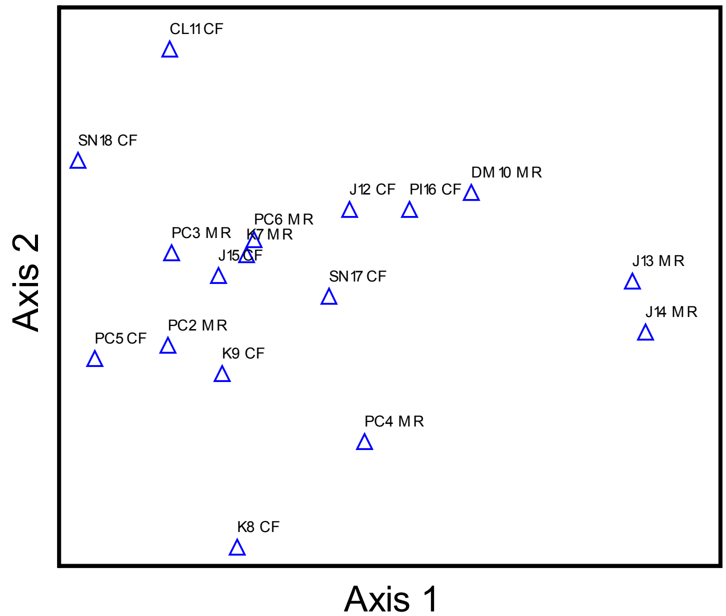


Figure 9. Detrended correspondence analysis (DCA) of 17 cottonwood forest and mixed riparian forest plots, using importance values of trees. Downweighting of rare species was used. Proximity of plots to one another indicates overall similarity in species space. Analysis was run without plot CL-1 (see text). About 40% of the variance is explained by Axis 1, and 20% by Axis 2. CL=Chico Landing, DM=Deadman's Reach, J=Jacinto, K=Kaiser, PC=Pine Creek, PI=Phelan Island, SN=Sul Norte.

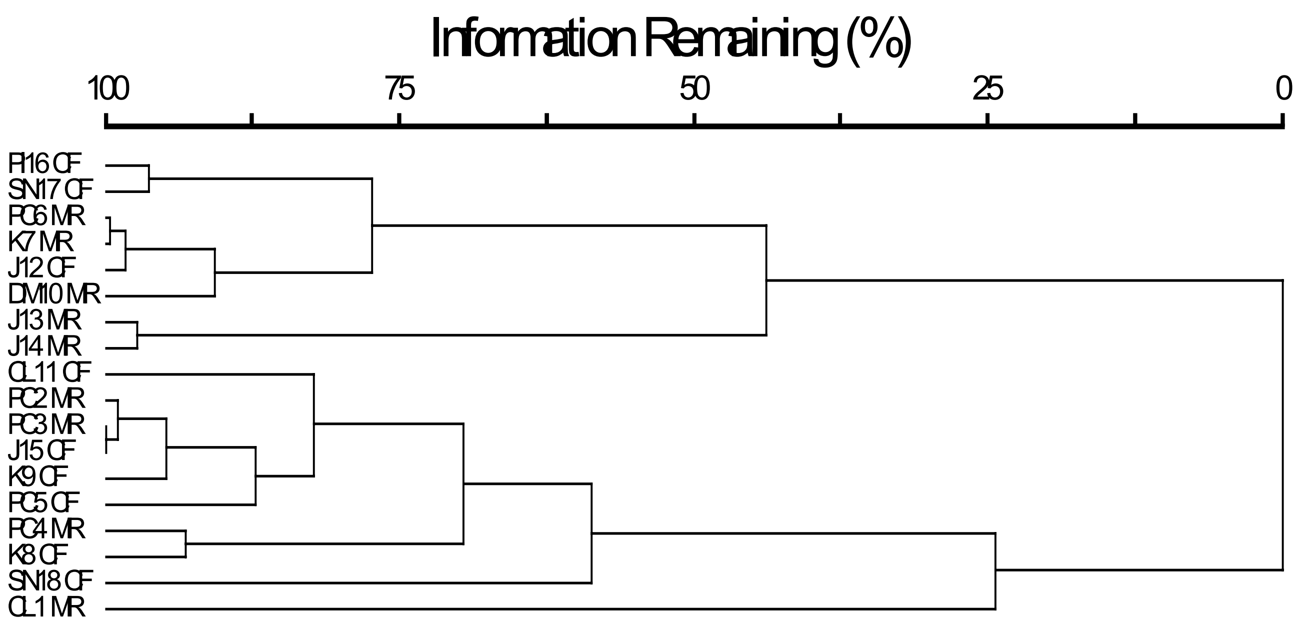


Figure 10. Cluster analysis of 18 Fremont cottonwood forest and mixed riparian forest plots, using importance values of trees and Euclidean (Pythagorean) Distance and Ward's method of clustering. CL=Chico Landing, DM=Deadman's Reach, J=Jacinto, K=Kaiser, PC=Pine Creek, PI=Phelan Island, SN=Sul Norte.

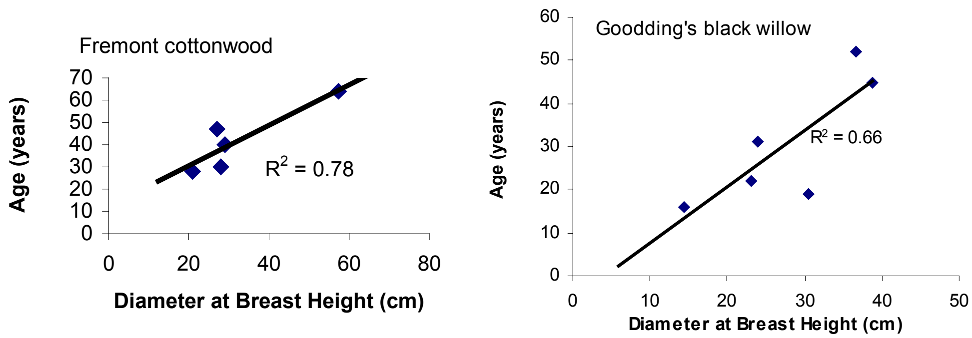


Figure 11. Regressions of tree size (diameter at breast height) on age (determined by ring counts). All regressions are significant at $p<0.01$.

Because the riparian communities on Battle Creek are spatially distributed along a more narrow corridor than those on the Sacramento River, plot shape and corresponding analyses may have to be altered to accommodate transects.

Costs are estimated from the Wood (2003) study and are combined below for the habitat characterization and growth increment coring components.

Growth increment coring component

Hypothesis: Because a positive correlation between rate of instream flow and rate of tree ring growth have been observed for riparian vegetation in California (Stromberg and Patten 1990, Stromberg and Patten 1991), increased baseflows on Battle Creek will result in more vigorous riparian vegetation growth rates.

Monitoring Goal: The goal of this study component is to quantify the growth rates of riparian species represented by the width of growth increments. This study has the added advantage of capturing true pre-project baseline conditions. An interim flow agreement has been in place for several years on Battle Creek, already resulting in increased baseflows. Consequently, existing growth rings will have captured any hypothesized response to this flow increase. Methods are again summarized from the Wood (2003) study.

> Three to four trees from within each plot or the immediate vicinity were selected for age determination. One tree each of Fremont cottonwood, California black walnut, box elder (*Acer negundo*), and Goodding's black willow (*Salix gooddingii*) was selected if present in the immediate vicinity. These species were selected because of their common occurrence throughout the study region. An increment corer was used to extract a 5 mm thick core, which was then placed into a plastic soda straw for transport back to the lab. The hole was then plugged with a twig dipped in tree wound healing compound to seal the cavity. If upon inspection a core did not have identifiable pith (tree center) it was discarded and another core was taken. In the lab cores were glued to wooden holders and sanded

smooth using 400 grit sandpaper. To facilitate counting age rings, cores were treated with 5% phloroglucinol in ethyl alcohol for 45 seconds and then acid-washed using 50% aqueous hydrochloric acid. This procedure stains lignin red and thus accentuates yearly growth rings because lignin is more concentrated in the smaller diameter xylem cells at the end of the growing season. Rings were counted using a dissecting microscope by two independent technicians and the tree ages compared. If there was a large discrepancy in calculated age (>3 years), a third independent count was done and the closer of the two values was used. If there was such a poor ring presentation that aging would be problematic, the core was discarded without further analysis.

The same data collection activities for this study component can also inform an analysis of age class structure. Although Wood did not analyze growth rings for growth rate (width) changes, they did develop regression relationships between age and diameter at breast height (DBH). Figure 11 shows these data, which could be used to create approximate age class structure at Battle Creek sites in parallel with growth rate analysis.

Costs

Objective/Year	2005	Year 5 after Restoration Project implementation (in 2005 dollars)	Year 10 after Restoration Project implementation (in 2005 dollars)
1. Baseline characterization of 42 stream miles			
1a. Flight and data processing	$84,000*	$84,000	$84,000*
1b. Photo interpretation and vegetation patch mapping	$1,794	$1,794	$1,794
1c. Contingency (15%)	$7,816	$7,816	$7,816
2. Baseline characterization of 5 indicator sites:	$60,000	$60,000	$60,000
Total	$153,610*	$153,610	$153,610*

- Assume 2 photos/mi. at $23/photo for photo interpretation.
- 15% contingency is required because scale of photography may be finer than the study from which these cost estimates were obtained.
- Indicator site costs and photointerpretation costs are estimated from Wood (2003) and are combined for the habitat characterization and growth increment coring components.
- Costs for aerial imaging developed based on discussions with Richard Duncan, GeoEngineers, Inc., Redmond, WA, see cold-water refuge Section IX for details; and the Wood 2003 study.
- * Approximately $84,000 could be saved from baseline and year 10 costs if this study and the cold-water refuge study were done simultaneously. Both these studies use much of the same data and methods and preliminary analysis. In years when this study and the cold-water study overlap, both studies could be done for $69,610 (non aerial riparian study) + $19,000 (non-aerial cold-water study) + $84,000 (aerial imaging) = $172,610 if done simultaneously. If done separately, they would cost $153,610 + $103,000 = $256,610.

Possible Adaptive Responses

The AMTT considers this riparian focused study to add to the important learning value of the Restoration Project identified by the technical review panel. Benefits to riparian habitats will very likely result from restoration project action. However, these benefits were never considered a project goal because the riparian habitats on Battle Creek are relatively intact. In part, this is due to steep topography significantly limiting streamside cattle access.

The AMTT sees the primary adaptive response regarding riparian habitat response on Battle Creek as applying new knowledge elsewhere. There are other tributaries in the Central Valley that are likely to be considered within the CALFED program for restoration actions in the future. Should these projects identify riparian vegetation within their project goals, example responses from Battle Creek may inform planning for these other efforts.

References

Auble, G. T. , J. M. Friedman, and M. L. Scott. 1994. Relating riparian vegetation to present and future streamflows. Ecol. Applications 4(3):544-554.

Barbour, M.G., J.H. Burk, W.D. Pitts, F.S. Gilliam, and M.W. Schwartz. 1999. Terrestrial Plant Ecology, 3rd Edition. Addison Wesley Longman, Menlo Park.

Borcalli, F., Gathard, D., Gregory, S., Rondorf, D., Stensby, D., and E. Wohl. 2003. Technical Review Panel Report, Battle Creek Salmon and Steelhead Restoration Project. September. 32 p.

Gregory, S. V., F. J. Swanson, W. A. McKee, and K.W. Cummins. 1991. An ecosystem perspective on riparian zones. Bioscience 4:540-551.

Greimann, B.P. 2001a. Hydrology of North Fork and South Fork Battle Creeks: Battle Creek Salmon and Steelhead Restoration Project, California. Prepared by USBR Technical Service Center. April.

Greimann, B.P. 2001b. Sediment Impact Analysis of the Removal of Coleman, South, and Wildcat Diversion Dams on South and North Fork Battle Creeks: Battle Creek Salmon and Steelhead Restoration Project, California. Prepared by USBR Technical Service Center. April. 33 p.

Jones & Stokes. 2003. Battle Creek Salmon and Steelhead Restoration Project Draft Environmental Impact Statement/Environmental Impact Report. July 2003.

Kier Associates. 2001b. Draft Battle Creek Salmon and Steelhead Restoration Project Adaptive Management Plan, Appendix D. September.

Kimmins, J. P. 1997. Forest Ecology 2nd Ed. Prentice Hall.

MacDonald, L.H., A. W. Smart, R. C. Wissmar. 1991. Monitoring Guidelines to evaluate effects of forestry activities on streams in the Pacific Northwest and Alaska. Water Division, EPA/910/9-91-001.

Platts, W. S., C. Armour, G. D. Booth, M. Bryant, J. L. Bufford, P. Cuplin, S. Jensen, G. W. Lienkaemper, G. W. Minshall, S. B. Monsen, R. L. Nelson, J. R. Sedell, J. S. Tuhy. 1987. Methods for evaluating riparian habitats with applications to management. USFS Tech. Rep. INT-221.

Stillwater Science 2004. Battle Creek Adaptive Management and Sediment Monitoring Plan: draft.

Stromberg, J. C. and D. T. Patten. 1990. Riparian vegetation instream flow requirements. Environ. Manage. 14(2):185-194.

Stromberg, J. C. and D. T. Patten. 1991. Instream flow requirements for cottonwoods at Bishop Creek, Inyo County, California. Rivers 2:1-11.

Stromberg, J. C., R. Tiller, and B. Richter. 1996. Effects of groundwater decline on riparian vegetation of the semiarid regions: the San pedro, Arizona. Ecological Applications 6:113-131.

Wood, D. M. 2003. The Distribution and Composition of Woody Species in Riparian Forests along the Middle Sacramento River, California. Department of Biological Sciences. California State University, Chico.

VIII. FOCUSED STUDY: JUVENILE SALMONID HABITAT USE STUDY

Many uncertainties were identified related to juvenile salmonid habitat use, distribution and abundance, some of which may be key to the success of the Battle Creek Salmon and Steelhead Restoration Project (Restoration Project). Testing some of these uncertainties may result in improvements in Restoration Project flows as well as aid in design of similar projects in other watersheds. The study will have three goals.

Goals

1) to verify the juvenile salmonid microhabitat suitability indices upon which the restoration project flows are based;

2) to document the distribution of juvenile salmonids in the restoration project area to verify successful passage, habitat occurrence and juvenile production; and

3) to estimate the relative abundance of juvenile salmonids in reaches of the restoration project to determine if they are using the reaches as predicted in conceptual and PHABSIM flow models.

Background

The restoration Project is a relatively high-cost project, designed using widely accepted processes such as limiting factor analysis, limiting life stage modeling, PHABSIM, SNTEMP, and barrier analysis. The restoration Project will implement widely accepted techniques of dam removal, fish ladder and fish screen construction and increased minimum flows. If these design processes and restoration actions or techniques do not work, other restoration efforts may also fail and waste money.

Many of the uncertainties associated with these processes and techniques are identified in the Restoration Project Adaptive Management Plan (AMP). The proposed study would address many of the key uncertainties. One of the primary features of the Restoration Project is increased minimum stream flows to provide salmonid spawning and rearing habitat. Habitat suitability indices used in prescribing flows for the Restoration Project were based on studies outside of the Restoration Project Area and may not be completely appropriate to each of the target species.

Battle Creek-specific juvenile habitat suitability criteria will be developed when there are sufficient numbers of juvenile salmonids. These Battle Creek specific criteria will be compared to those used in developing the Restoration Project. If considerable differences in criteria exist, model results using both criteria would be compared. Criteria will be developed using state-of-the-art techniques which take into consideration habitat availability, appropriate precision in measurement, and consideration of adjacent velocity. Spawning habitat suitability criteria are currently being developed for spring Chinook and steelhead in Battle Creek.

Many of the questions in the proposed study may be better addressed by estimating fish abundance rather than just fish distribution. It is uncertain if standard techniques for estimating abundance would be effective in Battle Creek. During a fish abundance study, it was concluded that electrofishing was not feasible as a calibration technique for the entire suite of fishes (TRPA 1990). Direct observation is not adequate for detecting the entire Battle Creek fish community or estimating abundance. The TRPA (1990) study stated "Results of initial field applications dictated that electrofishing effort be severely restricted and increased reliance placed on the direct observation technique". Other than one study site on the South Fork, "the remainder of the study sites were sampled by direct observation" which tended to favor the salmonid species.

Conceptual Model

The fundamental question addressed in this study is will Chinook and Steelhead successfully use Battle Creek as predicted in the conceptual models upon which the Restoration Project is based? The general approach is to verify the expected fish distribution and habitat use patterns by direct observation.

Uncertainties

The AMP includes an extensive list of uncertainties, many of which can potentially be evaluated by the proposed study. Uncertainties are arranged by study Goal. The uncertainty numbering system refers to nodes in Conceptual Models in the AMP (e.g. 2A = node A in Conceptual Model 2). Key uncertainties are indicated in bold.

Goal 1) to verify the juvenile salmonid microhabitat suitability indices upon which the restoration project flows are based;

2A – Uncertainties are inherent in the IFIM and PHABSIM models (Instream Flow Council (2002 and Castleberry 1996) including: 1) sampling and measurement problems associated with representing 42 miles of stream; 2) sampling and measurement problems associated with developing habitat suitability curves; and 3) problems with assigning biological meaning to weighted usable area; especially without presenting confidence intervals.

2A – Habitat suitability criteria curves developed in 1989 in TRPA 1998a, which were based on studies outside of the Restoration Project Area and were applied in the PHABSIM flow-habitat simulation for the three species targeted by the Restoration Project, may not be completely appropriate to each of the target species.

2H – IFIM results (WUA curves) cannot be confidently converted to estimates of fish production without validating the 1989 IFIM model for Battle Creek salmon and steelhead (e.g. establishing confidence limits and examining transects for significant changes in channel morphology and applying more appropriate habitat suitability curves, etc).

Goal 2) to document the distribution of juvenile salmonids in the restoration project area to verify successful passage, habitat occurrence and juvenile production;

3J-3Q, 2C How will juvenile production (growth, survival, distribution, outmigration) be affected by water temperature regime in warm season?

3K-3O Food production, predation risk, growth, competition, disease, and other factors of natural mortality. Low juvenile production threatens project success. Predictions of distribution and estimates of carrying capacity may be confounded. Rather than addressing the mortality factors, the proposed study would document the resulting distribution pattern.

2G To what extent will steelhead and four races of Chinook use the "A" and "B" grade habitats as predicted?

In addition, many of the key adult fish passage uncertainties will be tested indirectly by documenting juvenile fish distribution.

3I-3M How will spawning activity be distributed within the restored habitat that is made accessible by reducing natural obstacles with higher instream flows?

3H-3M How will spawning activity be distributed within the restored habitat that is made accessible by fail-safe fish ladders?

3C-3H Will fail-safe fish ladders insure adequate upstream passage at dams?

3D-3I Will new instream flows provide fish passage at natural obstacles that meets the level predicted using Powers and Orsborn methodology and will that level of passage meet or exceed that required for fish ladders?

Goal 3) to estimate the relative abundance of juvenile salmonids in reaches of the restoration project to determine if they are using the reaches as predicted in conceptual and PHABSIM flow models.

Goal 3 also addresses the uncertainties listed under goal 2.

<u>**Monitoring Goals and Objectives**</u>

Goal 1 is to verify the juvenile salmonid microhabitat suitability indices (rearing criteria) upon which the restoration project flows are based;

Objective 1 A- Develop Battle Creek-specific rearing criteria within 3 years of Restoration Project construction using observations from at least 250 juveniles of each species (MC 1; MC refers to monitoring components described in subsequent section)

Objective 1 B- Within three years of project construction qualitatively compare new spawning and rearing criteria to old criteria (MC 3). If sufficiently different proceed with Objective 1 C.

Objective 1 C- Determine if Weighted usable Area (WUA) calculated from the new spawning and rearing criteria are within 5% of the WUA used as the basis for RP flows. (MC 2)

Goal 2 is to document the distribution of juvenile salmonids in the restoration project area as an indication of successful passage, occurrence of habitat and juvenile production;

Objective 2 A- Estimate juvenile salmonid distribution in the anadromous reaches of Battle Creek in the year after implementation of the Restoration Project. Presence or absence of species within a reach will be estimated by direct observation at one or two sampling sites (MC 4) and incidental observations (MC 5).

Goal 3 is to estimate the relative abundance of juvenile salmonids in the anadromous reaches of Battle Creek for comparison to the relative habitat values as predicted by the conceptual models and PHABSIM flow-habitat simulation.

Objective 3 A- Estimate variability in juvenile salmonid density and calculate the number of observations required to have sufficient statistical power to distinguish (MC 6).

Objective 3B- Estimate juvenile salmonid density after the Restoration Project.

Objective 3C- Develop relative habitat values from the conceptual models and PHABSIM flow-habitat simulation and compare with juvenile salmonid densities observed in 3B.

Monitoring Components- under development

MC 1. *Develop new Battle Creek-specific juvenile habitat suitability criteria*

MC 2 *Compare new and old spawning and rearing criteria*

MC 3 *Compare PHABSIM runs using new and old criteria*

MC 4 *Distribution surveys.*

Juvenile salmonid distribution in the watershed will be compared to conceptual models of fish distribution, actual spawner distribution, water temperature and geographic features such as springs, and fish passage barriers.

Standard fisheries sampling using multiple techniques including electrofishing, seining, and direct observation, will be conducted at sites within all naturally anadromous reaches of Battle Creek. While one site will be selected within each of 18 reaches, a few additional sites will be selected to more clearly define the current upper ranges of the fishes. Note the similarity of this study to the proposed Fish Community Distribution Survey Focused Study which could be conducted in conjunction with the proposed study resulting in cost savings.

MC 5. *Incidental observations*.

Observations incidental to other fisheries monitoring, including snorkel surveys, habitat use studies, barrier weir monitoring, radiotelemetry and fish rescue will be incorporated into the analysis of fish species distribution.

MC 6 *Estimate feasibility and minimum population size for juvenile abundance study.*

This study will develop methods for abundance estimates especially considering questions of sample size, statistical power and timeline. One year of funding will be sought for the first year after the restoration project is completed and adult fish have been allowed access to the project area. Juvenile salmonid densities may be too low to achieve study objectives and may remain so for many years. Conducting the juvenile studies in the first year will aid in determining the feasibility and logistics of the study, as well as provide baseline data to track the projects' progress over time. During the pilot year, statistical analysis may be able to predict the juvenile population size and number of observations required to detect significant differences. Determining the statistical power of the study may aid in determining when there will be sufficient numbers of fish to begin the rest of the juvenile study. This trigger will be used to determine when to pursue funding for the rest of the study under MC 7.

The Restoration Project area will be habitat typed, and divided into reaches. Sites approximately 100 m in length, which include all major meso-habitat types, will be selected within each reach. Juvenile abundance will be determined at the sites by direct counts, by species and by size class. Relative abundance and distribution in the watershed will be compared to conceptual models of fish distribution, actual spawner distribution, water temperature and geographic features such as springs, and fish passage barriers.

MC 7. *Juvenile abundance study*

Components of this study to be determined by the feasibility study in MC 6.

Monitoring cost estimates

Sub Total Cost during Restoration Project (2005 – 2007) = $100,000 for pilot study in year three.

Approximately $200,000 per year for 2 years in future after sufficient numbers of fish have recolonized the habitat.

Possible Adaptive Responses

Adjust flows if warranted by improved flow model (MC 3) in conjunction with other elements such as temperature and barrier analysis. The WAF provides up to $3M to acquire additional flows in Battle Creek if needed.

References

TRPA (Thomas R. Payne and Associates). 1990. Draft Species Abundance Report Battle Creek. Prepared for California Department of Fish and Game.

IX. FOCUSED STUDY: FISH USE OF COLD-WATER REFUGES

Introduction

This focused study will attempt to quantify the contribution of the release of cold spring water to Battle Creek to increases in production of adult and juvenile salmonids. The release of cold spring water to Battle Creek is a prominent component of the Battle Creek Salmon and Steelhead Restoration Project. However, key uncertainties exist regarding the biological benefits of this project element. Also, the potential transferability of this approach to other watershed restoration projects is not well documented.

This study will have physical and biological components. The physical extent and distribution of cold-water refuges[1] will be compared between pre-project and post-project conditions to quantify the relative contribution of this Restoration Project element. Pre-project conditions include some natural spring releases and groundwater interaction with a stream network characterized by relatively low instream flows. These natural spring releases and groundwater interaction are hypothesized to behave as thermal point sources (Figure 1). The post-project conditions will have the same natural inflows of cold-water, plus the Restoration Project cold spring water releases, all within the context of relatively higher instream flows. The first physical component of the study will map, quantify, and compare changes in extent and distribution between these two conditions using aerial thermal imaging surveys. The physical mapping of cold-water refuges can be completed at the same time as aerial surveys of riparian habitat (see Riparian Vegetation Focused Study, Section VII) for little additional cost. The second physical component of this study will include the deployment of a network of automated temperature recording devices (in addition to those deployed for Habitat Objective 2) to record micro-scale water temperature affects within the three specific areas affected by Restoration Project cold-water releases. These thermisters will also facilitate the calibration of thermal imaging surveys.

The biological component of this study will examine the biological importance of cold-water refuges identified during the post-project physical mapping component. The utilization of cold-water refuges by juvenile and adult salmonids will be characterized and compared to habitat utilization of areas that are not influenced by cold-water refuges. The biological component of this study would necessarily occur at some future time when populations of juvenile and adult anadromous salmonids are at sufficiently high levels at which statistically meaningful responses could be measured (see similar concept in the Juvenile Habitat Use Study, Section VIII). The design of this biological study will begin with a review of the Contemporary cold-water refuge literature and a review of the pre- and post-project physical mapping. It may be prudent to link the biological component of this study with Juvenile Habitat Use Study (Section VIII) if feasible.

[1] Cold-water refuges, in general, are areas colder than a specified temperature (e.g. some thermal criteria suitable for salmonid survival and growth) within stream reaches characterized by ambient water temperatures greater than a specified temperature. The specification of these upper and lower temperatures will be determined from examination of Contemporary literature and will be measured empirically in the physical mapping component of this study.

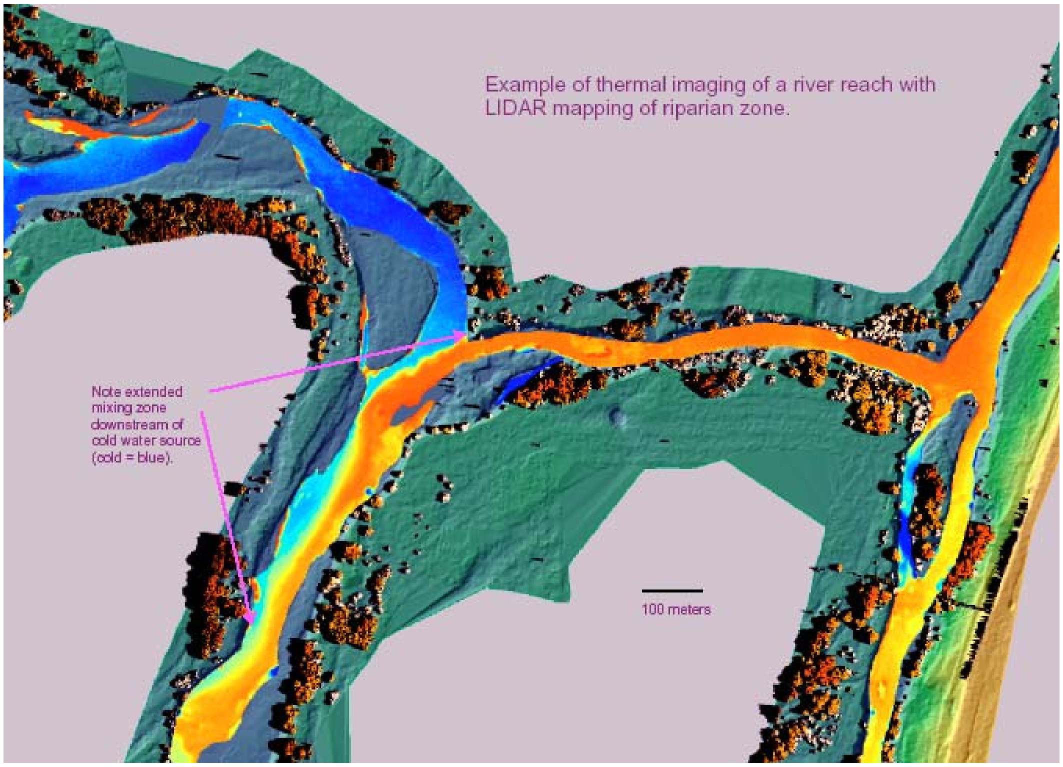


Figure 1. Example of thermal point sources.

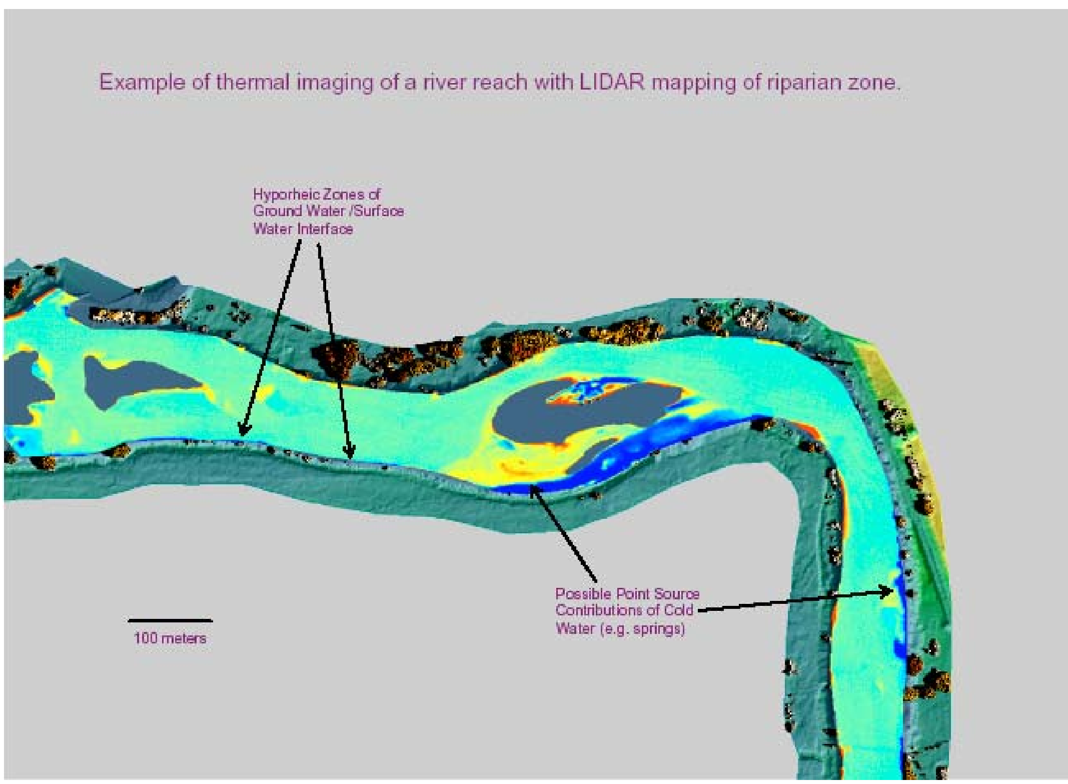


Figure 2. Example of thermal mixing zones.

Battle Creek Setting

A remarkable feature of Battle Creek is high volume of ground water that is contributed to the stream network during summer low-flow conditions (Ward and Kier 1999a). On average, the base flow of Battle Creek is approximately 250 cfs, the bulk of which enters the Battle Creek stream network directly from springs, seeps, and other hyporheic connections. Some seeps and springs arise in the uplands and flow to Battle Creek in tributary streams (e.g. Bluff Springs via Soap Creek flows at about 10 to 12 cfs, and Darrah Springs via Baldwin Creek will flow at 5 cfs after the Restoration Project). Other springs, such as Eagle Canyon Springs (flows at about 10 cfs) arise in riparian areas and immediately feed Battle Creek. Countless other, less-prominent areas of hyporheic connection, where cold-water seeps directly into the stream from the bed and banks, remain unnamed but are distributed widely within the North and South Forks of Battle Creek.

Under pre-Restoration Project conditions, many of the larger springs within the watershed, are captured in the hydroelectric project conveyance systems. An element of the Restoration Project is to restore the connectivity of some of these springs (Eagle Canyon Springs, Bluff Springs via Soap Creek, and Darrah Springs via Baldwin Creek) with Battle Creek.

An important aspect of the spring water is that is it relatively cold. For example, Eagle Canyon Springs are approximately 52 °F. In much of California, the temperature of surface waters often is near or in-exceedence-of the thermal criteria for anadromous salmonids, making water temperature a limiting factor in many streams. In Battle Creek, the abundant cold spring water cools most stream reaches to temperatures suitable for all or most life history stages of the native salmonids; this is perhaps the single most important characteristic of Battle Creek for fisheries restoration.

Conceptual Model

Battle Creek's cold spring water input can be thought of as playing two distinct roles in cooling the stream. The first concept is *reach-scale cooling* where the integrated contribution of many springs, or particularly voluminous springs, provides a general cooling affect on a macro-scale portion of the stream (i.e. stream reaches measured in kilometers). This concept of reach-scale cooling is what was used in Ward and Kier (1999a) for predicting which fish species and life stages would use the reaches of Battle Creek and in Tu's (2001) development of the predictive SNTEMP water temperature model. Habitat Objective 2 will employ this concept when monitoring the longitudinal water temperature regime of the stream to determine the attainability of water temperature goals. At this scale, cold water input is generally conceived as mixing completely and instantaneously with the ambient instream flow.

The second concept is that of *cold-water refuges*[1] which recognizes the contributions of individual cold-water sources at the meso- or micro-scales. At these smaller scales (meters to 10s of meters; see Figures 1 for examples of meso-scale point sources), it is apparent that spring water inputs do not mix completely or instantaneously with ambient stream flow, and in fact, often form distinct areas of cold water distinguishable from the relatively warmer stream environment (see Figure 2 for illustration of extended mixing zones). Juvenile and adult salmon and steelhead have been shown to recognize and use these "cold-water refuges." In critically warm stream reaches, cold-water refuges have been shown to be essential for the survival and production of some salmonids.

It is possible that extensive use of cold-water refuges in Battle Creek may alter the way we perceive reach classification systems and other models we used to inform the primary conceptual models for this AMP (see Conceptual Model 2). On the other hand, we may find that the relative contribution of cold-water spring releases provided by the Restoration Project is less important than we believed given the relative volume of these inputs compared to increased instream flows and the presumed abundance of other ground water connections.

Uncertainties

The AMP identifies three key uncertainties pertaining to possible changes in cold spring water releases to be implemented as part of the Restoration Project:

- **Will post project release of cold spring water result in predicted water temperatures targets in warm season?**
- **How are cooling affects of spring releases spatially distributed within stream network?**
- **Are there microhabitat benefits (thermal refuges) that could result from spring releases that were overlooked by reach-scale SNTEMP model?**
- **Uncertainties are inherent in SNTEMP model which averages temperatures by reach and over monthly time periods.**
- **Uncertainties are inherent Tu's (2001) application of the SNTEMP model in Battle Creek (e.g. is Redding climate data applicable to Battle Creek? What are the effects of canals and shading on thermal gain? Will potential temperature problems be restricted to June through September?)**
- **How will spawning success and egg survival be affected by water temperature regime in warm season?**
- **How will juvenile production (growth, survival, distribution, outmigration) be affected by water temperature regime in warm season?**

These uncertainties stem largely from a lack of detailed water temperature information and are exacerbated by simplistic assumptions within the SNTEMP water temperature model. SNTEMP assumes instantaneous mixing at thermal point sources when the actual contribution from thermal point sources takes place gradually over some longitudinal stream segment (Figure 1). These uncertainties also stem from lack of detailed information of how salmonids of various species at temperature-sensitive life stages will use habitats in Battle Creek.

Additional uncertainties regarding the distribution and habitat use of salmonid species and life stages can be addressed, in part, by comparing results from this study with the results of other monitoring elements like radiotelemetry, spawning and rearing distribution surveys, juvenile habitat use, and fish community structure. Fine-scale topographic information collected in this study may also help in the identification of potential natural fish barriers and assist in the implementation of the sediment monitoring study.

Possible Adaptive Responses

If cold-water spring releases are shown to have greater benefit than anticipated, then the AMPT may want to explore additional opportunities for acquiring and releasing more ground water to the stream. If cold-water spring releases are shown to have relatively less benefit than anticipated, then other future restoration projects would benefit from this knowledge in their ability to assess how to include spring releases into future project designs.

The California Wildlife Conservation Board and CALFED currently explores opportunities to obtain, from willing sellers, conservation water rights from cold water sources. These conservation water rights would allow the natural flow of cold water from springs or seeps into the Battle Creek stream channel.

Study Approaches

Goal 1. Understand the relative difference between pre-project and post-project contributions of cold spring water releases to reach-scale and meso-scale water temperature regimes.

Objective 1a. Quantify the amount of cold-water habitat and relative contribution of hyporheic connections in the 42 miles of mainstem, and North and South Forks portions of the Restoration Project area under pre- and post-project conditions through the use of aerial surveys using **t**hermal **i**nfra**r**ed (TIR) imaging and **li**ght **d**etection **a**nd **r**anging imagery (LIDAR), and GIS-based analysis. The purpose of this work would be to:

- quantify the wetted surface area at or below certain temperature criteria,
- map the distribution of cold-water habitat[2], and
- model the relative cooling effects of topographic and vegetative shading to separate those effects from hyporheic cooling effects.

Schedule for Objective 1a.

- Collect aerial imaging data and perform analysis during pre-project conditions in summer of 2005.
- Collect aerial imaging data and perform analysis during post-project conditions in year 10 after implementation of Restoration Project – as dictated by riparian vegetation study and juvenile fish abundance. Possibly link this to Juvenile Habitat Use study.

Deliverables for Objective 1a.

- All deliverables for objective 1a will be produced twice: once for pre-project and once for post-project conditions

[2] The AMTT will define "cold-water habitat" in absolute temperature units after we develop the vector contoured maps of isotherms because we may wish to use different temperature criteria for different life stages.

- Aerial imaging data collection on two occasions.
- Ortho-rectified color aerial photos (20 cm pixels) for whole study area – for use in vegetative mapping (see Riparian Vegetation Focused Study, Section VII), for use in modeling shade affects, and useful for checking georeferencing of all data layers.
- TIR data collection from whole study area.
- GIS map of TIR data for whole study area.
- Digital Elevation Model (DEM) and Digital Topographic Model with iso-vector contour map for whole study area – necessary to map water surfaces, also useful for other habitat work (e.g. channel morphology, identification of flood plains).
- Raw data in x, y, z ASCII format.
- Data summary report describing study objectives, technology and methods, work completed, results, deliverables, conclusions, and recommendations.

Objective 1b. Record micro-scale water temperature affects within the three specific areas affected by Restoration Project cold water releases using automated thermisters. The purpose of this work would be to:

- facilitate the calibration of thermal imaging surveys and to aid in design and implementation of biological study components.

Schedule 1b.

- Collect micro-scale water temperature data and perform analysis during pre-project conditions in summer of 2005.
- Collect micro-scale water temperature data and perform analysis during post-project conditions in summer of year 10 after Restoration Project implementation – as dictated by aerial imaging data collection , riparian vegetation study, and juvenile fish abundance. Possibly link this to Juvenile Habitat Use study.

Deliverables for Objective 1b.

- Data will be collected and summarized from up to 10 discrete locations at 3 Restoration Project cold water release sites (Eagle Canyon Springs, Bluff Springs and the mouth of Soap Creek, and Darrah Springs and the mouth of Baldwin Creek) using a network of 30 thermisters.
- These locations will be georeferenced by surveying them to a benchmark that can be identified in the aerial surveying so that thermister locations can be directly mapped on TIR images for TIR data calibration.

Goal 2. Understand the biological importance of cold-water refuges identified during the post-project physical mapping component.

Objective 2. The utilization of cold-water refuges by juvenile and adult salmonids will be characterized and compared to habitat utilization of areas that are not influenced by cold-water refuges. The purpose of this work would be to:

- refine estimates of fish habitat utilization and stream classification systems used in Conceptual Model 2.
- develop an understanding of the importance of restoring cold-water refuges in anadromous salmonid habitats of California.

Schedule 2. This work will best be performed once restored fish populations begin to utilize habitat throughout the Restoration Project area and once populations are at levels where density-dependent mechanisms would presumably result in a stronger fish habitat utilization signal. This work should be done in the same year as the post-project cold-water refuge mapping and calibration. We presume that sufficient levels of fish will be present by year 10 after Restoration Project implementation.

Deliverable for Objective 2. Because the biological importance of cold-water refuges is relatively poorly documented (at present) but is the subject of numerous on-going investigations, and because this study may not be conducted for at least 13 years from now, the design and pricing of this biological study will be deferred until year 8 after the Restoration Project is implemented. The design of this biological study will begin with a review of the Contemporary cold-water refuge literature and a review of the pre- and post-project physical mapping. It may be prudent to link the biological component of this study with Juvenile Habitat Use Study (Section VIII) if feasible.

Reporting and Analysis. Results from the aerial imaging and micro-scale thermister deployment will be described in a two reports (draft report for pre-project and final report for post-project). The final post-project report would include description of the biological studies. These results will be described in the context of Battle Creek adaptive management and will recommend changes to uncertainties, conceptual models, adaptive management objectives including possible adaptive responses, and future monitoring. The results will also be generalized to possible future restoration projects that might consider restoring cold spring water releases.

Cost Estimates

Objective/Year	2005	Year 10 after Restoration Project implementation (in 2005 dollars)
1a. Aerial Imagery and GIS Analysis.	$84,000*	$84,000*
1b. Micro-scale thermister deployment and analysis.	$4,000	$4,000
2. Fish utilization of cold-water refuges.	$0.00	To be determined
Reporting and Analysis	$15,000	To be determined
Total	$103,000	To be determined

Budget Notes:

- Aerial imaging costs were developed through discussions with Richard Duncan, GeoEngineers, Inc. Redmond, WA, who has conducted similar aerial imaging surveys, and were based on actual 2003 expenses for a similar study, adjusted for inflation to 2005. 42 miles x $2,000 per mile = $84,000.
- * Approximately $84,000 could be saved from pre-project and year 10 costs if this study and riparian vegetation study were done simultaneously. Both these studies use

much of the same data and methods and preliminary analysis. In 2005, when this study and the riparian vegetation overlap, both studies could be done for $69,610 (non aerial riparian study) + $19,000 (non-aerial cold-water study) + $84,000 (aerial imaging) = $172,610 if done simultaneously. If done separately, they would cost $153,610 + $103,000 = $256,610.

X. FOCUSED STUDY: BATTLE CREEK SALMONID LIFE HISTORY

X.A. Background

The Battle Creek Salmon and Steelhead Restoration Project (Restoration Project) and accompanying Adaptive Management Plan (AMP) includes the restoration of Battle Creek to assist in the recovery of four distinct runs of Chinook salmon and steelhead rainbow trout. The four runs of Chinook salmon include Winter-run, Spring-run, Fall-run and late-fall-run. Winter-run Chinook, Spring-run Chinook, and steelhead have been identified as the priority species for recovery because they are listed under the State and/or Federal endangered species act (CESA and ESA respectively) as either endangered (winter-run Chinook) or threatened (spring-run Chinook and steelhead. Fall-run and late fall-run are also runs included in the restoration goals for Battle Creek. They are listed as candidate species by ESA.

Each of the runs of Chinook salmon have unique life history characteristics for different phases of their life cycle. Winter-run Chinook salmon enter the San Francisco Bay from November through June. Their migration past Red Bluff Diversion Dam (RBDD) at River mile 242 begins in mid- December and continues into early August. The majority of the run passes RBDD between January and May, with the peak in mid-March (Hallock and Fisher 1985)

Winter-run typically spawn in their third year of life (Hallock and Fisher 1985), though a small percent return as two year olds and four year olds. Winter-run Chinook salmon typically spawn from late April through mid-August with the peak occurring in May and June. Prior to the construction of Shasta Dam, winter-run Chinook salmon spawned in the headwaters of the McCloud, Pit, and Little Sacramento Rivers (Yoshiyama et. al. 1998). Fry emergence occurs from mid-June through mid-October. Historical reports of naturally reproduced winter-run Chinook in Battle Creek of juvenile winter-run size salmon (Rutter 1903).

The residence time of juveniles in streams is less than a year (5-10 months) followed by an intermediate time in the estuary (Moyle 2002). Emigration past RBDD may begin in late July, generally peaks in September, and can continue until mid-March in drier years (Vogel and Marine 1991). Peak emigration through the San Francisco, San Joaquin Delta generally occurs from January through April, but the range of emigration may extend from September up to June (U.S. Fish and Wildlife Service 1994).

It is estimated adult Sacramento River spring-run Chinook salmon leave the ocean to start their upstream migration in late January to early February based on the time they start entering their natal tributary streams (CDFG 1998). The spring-run are not sexually mature when they enter the fresh water, but will mature during the spring and summer while in their natal streams (Marcotte 1984). Adults enter their natal tributary streams from mid-February through July with upstream migration peaking in May.

Currently, spring-run Chinook spawning occurs between mid-August and October. According to Harvey (1995) spring-run Chinook salmon in Deer Creek spawn first at higher elevations and cooler water temperatures and spawn progressively later as the elevation decreases and the temperature increases. It is expected the same type of activity would occur on Battle Creek. Currently spring-run Chinook salmon are limited in distribution to lower elevations in Battle Creek and their spawning activity occurs between mid-September and mid-October (Brown 2002). It is believed after restoration of Battle Creek, Spring-run Chinook salmon will be able to ascend to higher elevation in the watershed and spawning will occur earlier due to cooler water temperatures. Spawning further up in the watershed will also facilitate increased spatial and temporal separation from fall-run Chinook salmon.

Fall-run Chinook salmon are currently and historically the most abundant run of Chinook salmon in the Central Valley (Moyle 2002). They enter the River and migrate to their preferred tributary streams from July through September. They enter fresh water sexually mature and spawn from early October through December with peak spawning occurring in October and November. Since fall-run Chinook salmon are sexually mature when they start there upstream migration, they tend to spawn at elevations lower than 1,000 feet above sea level.

Juveniles emerge from the gravel and emigrate from January through June. The majority of fall-run Chinook salmon immigrate the first year, but a few may over summer in their natal stream if summer temperatures remain non-lethal. This strategy has allowed them to use large rivers and tributary streams that are too warm in the summer to support other runs of salmon.

Late fall-run Chinook salmon typically arrive in Battle Creek November through April with peak migration occurring in January generally as four and five year olds. Spawning typically occurs January through April with the peak in February and March. The juveniles emergence in April through June and will stay in the stream for seven to thirteen months (Yoshiyama et al 1998). Many of the juveniles may emigrate quickly from Battle Creek and complete rearing in the Sacramento River.

There is considerable overlap in the adult migration timing within Battle Creek, which complicates spawning escapement estimates. Genetic analysis is required to distinguish the four Chinook runs. The WHICHRUN analysis can distinguish winter from other Chinook on an individual basis. Previously WHICHRUN genetic analysis was provided under a contract which has expired with the Bodega Marine Laboratory which no longer performs this type of work. Additional funding and a new laboratory would be required to continue the genetic analysis. Genetic techniques capable of differentiating all Chinook runs on an individual basis have been developed by Dr. Michael Banks under a contract with the California Department of Water Resources.

The CALFED Science Panel report on the “Compatibility of Coleman National Fish Hatchery Operations and Restoration of Anadromous Salmonids in Battle Creek” made recommendations for genetic studies, including: “We therefore recommend an immediate (genetic) study to determine the reliability of separating unmarked spring and fall Chinook salmon at CNFH on the basis of visual methods” (pg. 8). “Spring Chinook salmon that spawn late in the run may be prone to hybridize with fall Chinook salmon that spawn early. We expect that the probability of hybridization will diminish over generations as the populations adapt genetically to the "new" conditions. During the interim, however, actions to avoid hybridization may be necessary. The obvious action is to reduce the numbers of fish that overlap in spawning time the consequent loss of the genetic integrity (due to hybridization) could be disastrous” (pg.

27), and "Because it seems impossible to block all fall and late-fall Chinook salmon, we also recommend intense genetic monitoring to detect any hybridization as early as possible" (pg. 28).

X.B. Battle Creek Setting

Battle Creek enters the Sacramento River near the town of Cottonwood approximately 25 river miles downstream of Keswick Dam. The importance of Battle Creek for its many resources was recognized as early as the late 1800's. Spawning salmon were recorded in the Creek in 1897, and the first hatchery reared salmon were released into Battle Creek in 1898 (CFC 1900). Constant high flow also made Battle Creek a prime stream for hydroelectric development. Because of the multitude of human activities during the last 100 years, Battle Creek's diverse anadromous fish population has significantly declined. The demonstrated persistence of the various anadromous species inhabiting Battle Creek is a key factor in concluding wild populations could again flourish if habitat improvements are made to better support the various fish life stages. Recovery of an assemblage of several listed species in Battle Creek would contribute significantly to reversal of the decline of these populations as a whole.

Battle Creek offers an extraordinary restoration opportunity because of its geology, hydrology, and habitat suitability for several anadromous species in a restored stream environment. The geology of the Battle Creek watershed, located at the southern end of the Cascades, is primarily volcanic in nature. This type of terrain provides deeply incised, shaded, cool stream corridors and its ruggedness limits the extent of human activities that typically occur around more readily accessible streams. Although substantial quantities of water have been diverted for hydroelectric production since the early 1900s; other activities that could have had potentially detrimental impacts on the stream and surrounding riparian environment have been effectively precluded by the nature of the terrain.

Battle Creek also has great potential for restoration because of the volcanic nature of the drainage. Seasonal precipitation does not rapidly run off the watershed as with streams situated farther south in the Sierra Nevada. Instead, a large portion of the annual precipitation percolates through the underlying volcanic strata and emerges throughout the watercourse as cold springs that ensure a relatively high and stable base flow throughout the year. The naturally regulated stable base flow and cold water temperature offer drought resistance rarely found in the present range of anadromous fish. Because of this hydrology Battle Creek offers natural habitat conditions conducive to the recovery of species no longer able to access all of their ancestral streams.

X.C. Study approach

Many of the criteria used to measure success of Battle Creek restoration rely on assessments of adult and juvenile populations of each of the targeted species and runs. Some of the uncertainties identified in the AMP include whether populations of targeted salmonids will respond favorably to the increased habitat created by the restoration efforts, and the ability to accurately quantify juveniles of each run of Chinook salmon. Current and proposed ongoing downstream migrant rotary screw trapping studies will help in answering overall juvenile abundance uncertainties. However, current studies use length at date data from Fisher (1992) for assigning a run designation based on measurements from fall-run Chinook salmon raised in artificial channels at the Tehama-Colusa fish facility which is no longer in operation. There is uncertainty whether these criteria can be used for different runs of salmon reared in the Sacramento River tributaries such as Battle Creek.

To address these uncertainties we propose the following studies:

X.C.1. Collect tissue samples for juvenile salmonids for genetic analysis and length at date evaluation.

Hypothesis: Using the date adults of each run of salmon spawn, the known temperature of Battle Creek, the time juveniles emerge, and current genetic analysis techniques, an accurate length at date determination can be made for each run of juvenile salmonid in the creek.

Monitoring Goal: The goal of this study is to collect information to accurately determine the run of individual juvenile Chinook salmon based on size at date criteria. This will be accomplished by collecting a non-lethal tissue sample from juvenile Chinook salmon captured in a rotary screw trap currently operated by the USFWS upstream of CNFH and sent to a qualified genetics lab for evaluation. This tissue sample will likely consist of a small fin clip commensurate to current genetic tissue collecting techniques. The date of capture, length of each Chinook salmon, and tissue sample number will be recorded. This information will be compared to adult spawn timing, stream temperatures, and genetic analysis as they are determined for each sample. Current genetic analyses techniques are accurate for determining presence and absence of winter-run genotypes. This will be valuable in distinguishing the two primary target species which are spring-run and Winter-run Chinook salmon.

Fall-run and late fall-run Chinook salmon will likely be detained from the project area until viable populations of the other two runs have been established. The current technology for genetic determination is progressing rapidly and some researchers believe they can distinguish between runs of Chinook salmon with varying degrees of accuracy at this time. When these runs are reintroduced the genetic sampling protocol may need to be reevaluated.

The desired product will be a usable technique for determining Battle Creek juvenile Chinook salmon run based on size criteria. This technique can also be compared to current studies being conducted on other Sacramento River tributaries like Clear Creek, Deer Creek, and Mill Creek.

X.C.2. Collect juvenile salmonids near spawning areas.

Hypothesis: Juvenile salmonids collected by non-harmful techniques near spawning areas could help determine emergence timing and therefore run designation.

Monitoring goal: The goal of this study is to collect juvenile salmonids near known spawning areas to determine the date the fish emerged from nearby redds. This will be accomplished using small beach seines or electrofishing equipment. The date of emergence can be estimated from known spawn timing and water temperature data. During the time period emergence is likely to occur, a team of two researchers will seine or electrofish areas of low water velocity near known redd sites and attempt to collect juvenile fish. Fish collected will be identified to species, measured to the nearest millimeter, have tissue removed (optional), and be released to the creek. Any collection of tissue samples will follow the previously mentioned protocol.

X.C.3. Distinguishing Runs of Chinook at Adult Life Stage

The first step of genetic analysis of Battle Creek Chinook would be to characterize the baseline of the existing samples collected from 1996 to present of fish from all runs. While 200 samples of each run would be desirable, at least 100 samples would be required. This baseline would then be used to assign runs to Chinook sampled in the future at the barrier weir and from snorkel survey carcasses. The baseline would also be used to assign runs to Chinook juveniles sampled by rotary screw trap or potentially by seining, to develop the run specific designation criteria. The genetic techniques could also be directly applied by sub sampling juveniles collected by screw trapping.

Goal 1) to develop methods to distinguish 4 runs of salmon during the adult life stage to improve escapement estimates, juvenile production estimate and fishery management.

Objectives: A) develop genetic baseline from previously-collected samples of adult Chinook.

B) apply genetic techniques to samples from barrier weir to produce escapement estimates.

C) use genetic techniques to evaluate ability of visual techniques to separate spring and fall Chinook.

D) apply genetic techniques to juveniles to evaluate ability of temperature unit analysis to create a run specific designation criteria.

E) apply genetic techniques directly to juvenile samples to correct past and future juvenile production estimates.

X.C.4. Total Cost

The total cost for all elements of this life history study is $373,081.

X.C.5. Possible Adaptive Responses

There is uncertainty whether we can distinguish between runs of Chinook salmon using date at length criteria coupled with genetic analysis. As we learn more of the capabilities of genetic analysis, we can refine our sampling collection techniques to increase the reliability of this tool.

X.C.6. References

Brown, M.R. and J.M. Newton. 2002. Monitoring adult Chinook salmon and steelhead in Battle Creek, California in 2001. USFWS Report. U.S. Fish and Wildlife Service, Red Bluff Fish and Wildlife Office, Red Bluff, California.

California Fish Commission (CFC) 1900. Fifteenth biennial report of the State Board of Fish Commission of the State of California for the years of 1897-1898.

California Department of Fish and Game. 1998. A status review of the spring-run Chinook salmon (*Oncorhynchus tshawytscha*) in the Sacramento River drainage. Candidate species status report 98-01. June 1998..

Fisher, F.W. 1992. Chinook salmon, Growth and Occurrence in the Sacramento River-San Joaquin River System. IFD Office Report 1992.

Hallock, R.J. and F.W. Fisher. 1985. Status of winter-run Chinook salmon, Oncorhynchus tshawytscha, in the Sacramento River. California Department of Fish and Game, Anadromous Fisheries Branch Report. nnpp.

Harvey, C.D. 1995. Annual Deer Creek Adult Spring-run Chinook Salmon Survey. Office Memo to file. August 22, 1995. Calif. Dept. of Fish and Game, Inld. Fish. Div. Red Bluff. CA.

Marcotte, B. D. 1984. Life history, status, and habitat requirements of spring-Chinook salmon in California. Unpubl. Report. USFS, Lassen National Forest, Chester, California. 34 pp.

Moyle, P.B. 2002. Inland Fishes of California: Revised and Expanded. Berkeley, CA: University of California Press.

Rutter, C. 1903. Natural history of the quinnat salmon: A report on the investigations in the Sacramento River, 1896-1901: Extracted from U.S. Commission Bulletin for 1902. Pages 86 to 131, Plates 10 to 18.

U.S. Fish and Wildlife Service. 1994. Abundance and survival of juvenile Chinook salmon in the Sacramento-San Joaquin estuary. 1993 Annual Progress Report. USFWS, Fishery Resource Office, Stockton, CA December 1994. 100 pp.

Vogel, D.A. and K.R. Marine. 1991. Guide to upper Sacramento River Chinook salmon life history. Prepared for U.S. Bureau of Reclamation by CH2MHill.

Yoshiyama, R.M., F.W. Fisher, and P.B. Moyle. 1998. Historical abundance and decline of Chinook salmon in the Central Valley region of California. North American Journal of Fisheries Management. 18:487-521

XI. FOCUSED STUDY: FISH COMMUNITY STRUCTURE EVALUATION

The proposed focused study will estimate changes in the distribution of fish species in anadromous reaches of Battle Creek and estimate the feasibility of making abundance estimates for a few species. Cost estimates are provided for a year of baseline data from pre-project conditions and a year of sampling 3 to 5 years after the restoration project is complete.

Background

The goals of the Battle Creek Salmon and Steelhead Restoration Project (Restoration Project) include restoring about 48 miles of anadromous fish habitat in Battle Creek and its tributaries and minimizing the loss of renewable energy produced by the Battle Creek Hydroelectric Project. The Restoration Project includes removal of dams; construction of fish screens, fish ladders, stream gages, and other facilities; and changes to stream flow (Jones & Stokes 2003).

Many of these Restoration Project elements may impact the distribution of non-target fish species.

Changes in the Battle Creek fish community may impact the target salmon and steelhead populations through competition or predation. These interspecific interactions are currently not considered key to the success of the Restoration Project nor important in choosing between adaptive management alternatives. However, there is enough uncertainty in our understanding of the ecological role of these interspecific interactions, to warrant baseline studies to evaluate the impact of the Restoration Project on fish distribution.

The footprint of the Restoration Project includes the expected range of the pikeminnow-hardhead-sucker fish assemblage (Moyle 2002) referred to here as the foothills assemblage. For instance, in Deer Creek which like Battle Creek also drains Mount Lassen, the assemblage ranges from 91 m (300 feet) to 550 m (1805 feet). Based solely on elevation the foothills assemblage could therefore range in Battle Creek from the confluence with the Sacramento River almost to the North Battle Feeder Dam on the North Fork (2060 feet) and South Diversion Dam on the South Fork (2030 feet) which are the upstream-most project features of the Restoration Project. However, at these elevations, water temperatures are lower in Battle Creek than in Deer Creek (Ward and Kier 1999). Battle Creeks high base flow and cool water temperature may reduce the upstream range of some species.

In a 1989 study of fish abundance in Battle Creek, most of the species of the foothills assemblage were not found upstream of Eagle Canyon Dam (1420 feet) and Inskip Diversion Dam (1410 feet) (TRPA 1990). The TRPA study noted that non-game species were more abundant in downstream reaches and bass were limited to the mainstem. The foothills assemblage also includes tule perch, speckled dace, California roach riffle sculpin, and rainbow trout, as well as introduced species such as smallmouth bass and green sunfish (Moyle 2002) .

The Restoration Project may also change the distribution or abundance of four watch-list species: hardhead (Mylopharodon conocephalus), river lamprey (Lampetra ayresi), western brook lamprey (L. richardsoni), Pacific lamprey (L. tridentata). A Watch-list species "appears to be declining but is not yet in serious trouble. Its populations needs to be monitored to see if special protective action is necessary" (Moyle 2002). Positive or negative impacts to these species may be detected by relatively simple presence absence surveys.

Abundance estimates of these species would also be very useful in understanding the issues involving competition and rare species, but it is uncertain if standard techniques would be effective. During the TRPA fish abundance study, it was concluded that electrofishing was not feasible as a calibration technique for the entire suite of fishes (TRPA 1990). Direct observation alone is not adequate for detecting the entire Battle Creek fish community or estimating abundance. The TRPA study stated "Results of initial field applications dictated that electrofishing effort be severely restricted and increased reliance placed on the direct observation technique". Other than one study site on the South Fork, "the remainder of all study sites were sampled by direct observation" which "tended to favor the salmonid species" (TRPA 1990).

However, electrofishing may be effective for estimating abundance of a single guild such as lampreys. The feasibility of developing abundance estimates for the lamprey species will be investigated. It is uncertain if the three lamprey species all inhabit Battle Creek. There is little information on lamprey species in Battle Creek as these cryptic species reside in silt or sand substrate, identification procedures for their larval stages require sacrificing the animals to count meristic characteristics, and they are not retained by the Coleman National Fish Hatchery barrier weir fish trap.

Physical setting

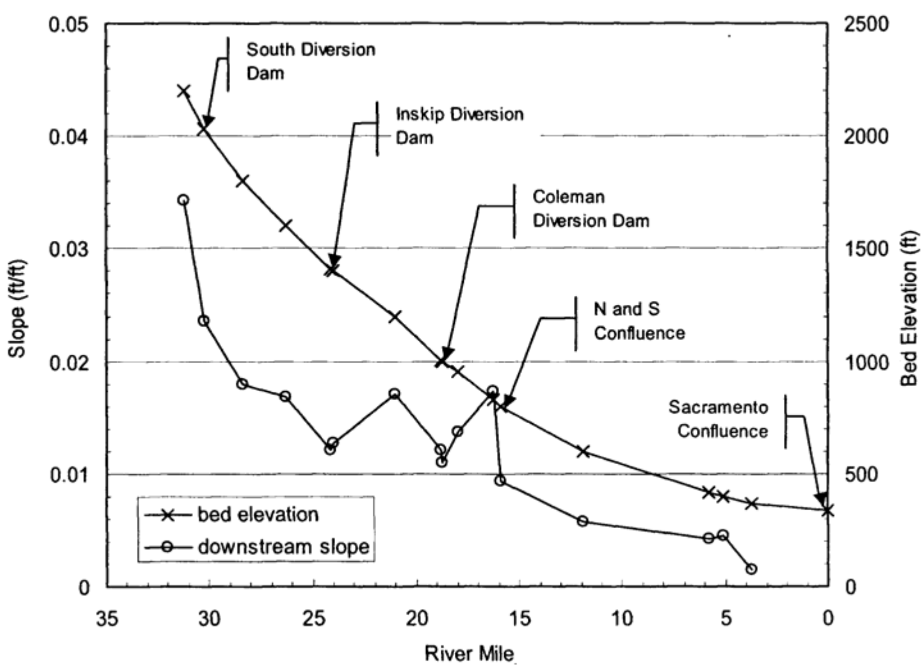


Figure 1. Bed profile of South Battle and Battle Creeks. Modified from Greimann 2001b.

Uncertainties

Uncertainties and learning opportunities pertaining to possible changes in fish community structure will arise from Restoration Project implementation, especially from Dam removal and changes in flow and water temperature regime

- How will fish species distribution change?
- How will these changes relate to changes in water flow and temperature?
- Will populations of potential predators of RP target species increase?
- Will populations of watch species increase?

Conceptual Model

Dams, diversions and natural barriers in Battle Creek may restrict the distribution of the foothills stream assemblage by blocking fish passage, entrainment of fish into the canal system, and alterations of the thermal regime. Removal of the dams may increase the range of many species including predators or competitors which could have an impact on restoration Project target salmonids. An important assumption is that dams and water diversions have restricted the distribution of fishes in Battle Creek.

There is uncertainty in how the fish species distribution will change in response to the Restoration Project. Increased fish passage may allow the upstream extension of the range of non-target anadromous species and predator species. The restoration project will produce complex changes in water temperature. Water temperatures may be higher or lower than pre-project conditions depending on time of year and location. These changes in water temperature may favor some species resulting in changes in fish species distribution.

Hypotheses

- The distribution of the foothills assemblage will increase upstream following the Restoration Project.
- The distribution of predatory species will increase upstream following the Restoration Project.
- Watch-list species will increase in abundance and distribution following dam removal.
- Changes in fish distribution will be related to changes in water temperature.
- Changes in fish distribution will be related to improvements in fish passage.

Monitoring Goals and Objectives

Goal- Estimate changes in fish community distribution or abundance which may affect the success of the restoration project or which may result from the Restoration Project.

Objectives (MC refers to monitoring components described in subsequent section)-

1) Estimate fish species distribution in the anadromous reaches of battle creek immediately before and a few years after implementation of the Restoration Project. Presence or absence of species within a reach will be estimated using one or two sampling sites (MC 2) and incidental observations (MC 5).

2) Estimate feasibility of estimating abundance of a few target species such as predators or lamprey immediately before and a few years after implementation of the Restoration Project. Population of predators and hardhead will be indexed (MC 1). Population abundance of lamprey will be estimated (MC 3). Juvenile abundance estimates (MC 4) will also be evaluated.

Monitoring components

MC 1. Snorkel surveys of entire project area for large bodied fishes.

Snorkel surveys of Battle Creek would be conducted to obtain population indexes for large bodied species, including pikeminnow, hardhead, Sacramento sucker, and smallmouth bass. Counts of rainbow trout are currently conducted during existing salmonid snorkel surveys and are not included as part of this survey. Snorkel counts would be used to index populations of pikeminnow and bass that could be predators of the Restoration Project target salmonids.

The large bodied fish surveys would be conducted separately from the salmonid surveys, to insure more complete counts and because methods differ slightly between the two surveys. Centrarchids larger than 9 inches and cyprinids larger than 12 inches will be counted by 3 snorkelers using standard direct observation techniques. Four surveys would be conducted during approximately one year to capture seasonal variability and determine the best time of year to base the index.

MC 2. Distribution surveys.

Standard fisheries sampling using multiple techniques including electrofishing, seining, and direct observation, will be conducted at sites within all naturally anadromous reaches of Battle Creek. While one site will be selected within each of 18 reaches, a few additional sites will be selected to more clearly define the current upper ranges of the fishes.

MC 3. Feasibility-level abundance estimates.

More intensive electrofishing will be conducted in a few sites to determine the feasibility of estimating the abundance of the 3 lamprey species. If feasible and within cost constraints, baseline abundance estimates will be made. Sites would ideally include habitat above and below the current distributions, including sites on both forks and the mainstem. The study would be dependant upon results from distribution surveys to determine the best sites for sampling.

MC 4. Rotary screw trapping.

Two rotary screw traps have been operated on Battle Creek starting in 1998. All non-larval fish are identified and counted, and a subsample is measured. Catch data expressed as fish per acre foot will be compared before and after the Restoration Project to detect large changes in abundance of juvenile fish.

MC 5. Incidental observations.

Observations incidental to other fisheries monitoring, including snorkel surveys, habitat use studies, barrier weir monitoring, radiotelemetry and fish rescue will be incorporated into the analysis of fish species distribution.

Monitoring Cost Estimates

Baseline study

MC 1	$28,600
MC 2	$95,700
MC 3	$28,050
Total	$152,350

Post project study

MC 1	$47,500
MC 2	$137,500
MC 3	$31,875
Total	$216,875

Possible Adaptive Responses

Increases in distribution or abundance or concentrations of predatory fish could suggest a follow-up predator investigation, or changes in facilities that may concentrate predators.

Increases in distribution or abundance of the watch-list species could suggest that dam removal or flow restoration may be a tool for improving populations of these fishes.

Declines in distribution or abundance of the watch-list species could suggest further studies or remedial actions.

Table 1. Fish species observed or suspected to occur in Battle Creek based on monitoring by U.S. Fish and Wildlife Service.

Common Name	Latin Name	Native/ Invasive	Observed/ suspected
Black Bullhead	*Ameirurus melas*	I	O
White Catfish	*Ameirus catus*	I	O
Brown Bullhead	*Ameirus nebulosus*	I	S
Sacramento Sucker	*Catostomus occidentalis*	N	O
Prickly Sculpin	*Cottus asper*	N	O
Riffle Sculpin	*Cottus gulosus*	N	O
Western Mosquitofish	*Gambusia affinis*	I	O
Threespine Stickleback	*Gasterosteus aculeatus*	N	O
California Roach	*Hesperoleucus symmetricus*	N	O
Tule Perch	*Hysterocarpus traski*	N	O
Channel Catfish	*Ictalurus punctatus*	I	O
River Lamprey	*Lampetra ayresi*	N	S/O
Western Brook Lamprey	*Lampetra richardsoni*	N	S/O
Pacific Lamprey	*Lampetra tridentata*	N	S/O
Hitch	*Lavinia exilicauda*	N	O
Green Sunfish	*Lepomis cyanellus*	I	O
Bluegill	*Lepomis macrochirus*	I	O
Smallmouth Bass	*Micropterus dolomieui*	I	O
Spotted Bass	*Micropterus punctulatus*	I	O
Largemouth Bass	*Micropterus salmoides*	I	O
Hardhead	*Mylopharodon conocephalus*	N	O
Golden Shinner	*Notemigonus crysoleucas*	I	O
Rainbow Trout/Steelhead	*Oncorhynchus mykiss*	N	O
Chinook Salmon	*Oncorhynchus tshawytscha*	N	O
Sacramento Pikeminnow	*Ptychocheilus grandis*	N	O
Speckled Dace	*Rhinichthys osculus*	N	O

References

Moyle, Peter B. 2002. Inland Fishes of California. University of California Press, Berkeley and Los Angeles California.

TRPA (Thomas R. Payne and Associates). 1990. Draft Species Abundance Report Battle Creek. Prepared for California Department of Fish and Game.

Ward, M. B., and W. M. Kier. 1999. Battle Creek salmon and steelhead restoration plan. Report by Kier Associates to Battle Creek Working Group.

XII. DIAGNOSTIC STUDY: FISH LADDER AND NATURAL BARRIER ASSESSMENT USING RADIOTELEMETRY

Introduction. The CALFED Technical Panel Report suggests in Section 3.1.2 that post-construction evaluation of the fish ladders proposed for the Battle Creek Salmon and Steelhead Restoration Project should include a more intensive evaluation of the movement and possible delay of adult salmon through the fish ladders. Because the ladder designs incorporated all appropriate features determined necessary and feasible by a multi-agency design team, the Adaptive Management Team had originally viewed an intensive passage study as unnecessary unless the proposed ladder passage counts and visual operations during other monitoring provided reason to suspect a problem may exist. In response to the Technical Panel suggestions that a radio-tag study should be conducted, the following study concepts are presented to examine Passage Objectives 1 and 3 from the Adaptive Management Plan (upstream passage of adult salmon and steelhead at dams and over natural obstructions).

Steelhead distribution surveys are a required element of the Restoration Project MOU. CALFED has funded a 2 year study to evaluate the feasibility of using kayak-based steelhead redd surveys for to meet long term population monitoring needs in Battle Creek. Although the kayak survey has not been completed, it appears likely that it will not be able to achieve Restoration Project goals. Use of radiotelemetry to monitor the distribution of steelhead may be the only feasible option for the Restoration Project. Therefore, radiotelemetry has become a higher priority.

Measuring or verifying fish passage is important in meeting AMP Fish Passage objectives. Although Restoration Project fish ladders were designed with high standards, using modern procedures, the constructed ladders may not function as intended. The Restoration Project increased minimum flows were prescribed specifically to allow fish passage at barriers identified in a 1989 barrier study (TRPA). The natural barriers in Battle Creek mostly consist of boulder clusters which form small plunges, waterfalls and chutes. The boulder clusters can shift and move over time. For instance, a barrier has evolved on the North Fork since the TRPA study which in 2001 and 2002 blocked spring Chinook passage at flows of 30 cfs (Brown and Newton 2002, Brown et al 2004).

The following are key uncertainties that could be addressed through the proposed radiotelemetry study.

3I-3M How will spawning activity be distributed within the restored habitat that is made accessible by reducing natural obstacles with higher instream flows?

3H-3M How will spawning activity be distributed within the restored habitat that is made accessible by fail-safe fish ladders?

3C-3H Will fail-safe fish ladders insure adequate upstream passage at dams?

3D-3I Will new instream flows provide fish passage at natural obstacles that meets the level predicted using Powers and Orsborn methodology and will that level of passage meet or exceed that required for fish ladders?

Null Hypothesis. After completion of the Battle Creek restoration project, anadromous salmonids will be able to pass fish ladders at North Battle Feeder Diversion Dam, Eagle Canyon Diversion Dam, and Inskip Diversion Dam and potential natural barriers downstream of those fish ladders within three days of encountering each point. Results will have to take into account natural factors that could delay transit time, such as very cold temperatures or very high flows.

Alternative Hypothesis. In the absence of natural factor to delay transit time, passage at natural barriers and dams is delayed longer than three days of encountering each obstruction and may require some sort of remedial action.

Study Period. In order to allow for the evaluation of fish movement in a variety of flow conditions and water year types the AMPT proposed to study the movement of tagged steelhead and spring Chinook salmon for three migration seasons after the ladders are constructed. This proposal details $210,517 in costs for the first year of such a study, for inclusion in initial funding for the Restoration Project. The estimate assumes that the USFWS to do work with existing gear. The costs to do the work with all new equipment would be $318,725. Costs for two follow-up years would be similar, approximately $211,000 per year, to account for equipment replacement and inflation.

Study Concept , Radio Tagging Study

To assess upstream movement of steelhead and salmon in Battle Creek under the modified flows and project configurations, 50 adult steelhead and 50 spring Chinook would be to radio-tagged when collected at the CNFH barrier weir, to track their movement in the watershed. Radio-tags are proposed rather than alternative methods (e.g. half-duplex PIT tags) because they allow the tracking of the movement of individual fish using both fixed and mobile receivers, which will more complete analysis of the upstream movements and distribution of tagged fish. In comparison, PIT-tagged fish can be monitored effectively only as they pass fixed sites. However, radio tags are expensive ($200/each) and involve greater tagging stress than PIT tags. Thus a relatively small sample size would be needed for a radio tracking study.

Proposed Monitoring Sites:

1. Battle Creek downstream of CNFH counting weir (to assess fallback)
2. Battle Creek upstream of Coleman P.H.
3. N.F Battle Creek at mouth.
4. S.F. Battle Creek at mouth
5. N.F Battle Creek downstream of known natural barrier at river mile 3.05
6. N.F Battle Creek upstream of known natural barrier at river mile 4.5.
7. N.F Battle Creek downstream of Eagle Canyon Diversion.
8. Entrance to Eagle Canyon fish ladder

9. Exit to Eagle Canyon Fish Ladder
10. N.F. Battle Creek downstream of North Battle Creek Feeder Diversion
11. Entrance to North Battle Creek Feeder fish ladder
12. Exit to North Battle Creek Feeder fish ladder
13. S.F. Battle Creek downstream of Inskip Diversion
14. Entrance to Inskip Diversion fish ladder
15. Exit to Inskip Diversion fish ladder

Remote monitoring stations at these points will allow assessment of fish movement after handling and tagging (sites 1 & 2), searching behavior at the confluence of the forks (sites 3 & 4), behavior at natural barriers in the North Fork Battle Creek (sites 5 & 6), and arrival at and passage through each of the three fish ladders (sites 7-15). In addition to fixed tracking sites, mobile tracking will be conducted during the course of other studies including temperature monitoring, juvenile habitat use monitoring, fish community monitoring, and especially snorkel surveys.

Radio Tracking Cost Estimate	# of Units	Unit Price	Total
Receiver/data logger w/DSP & multiple antennas for dams & ladders	1	$17,000	$17,000
Receiver/data logger w/ multiple antennas & solar system for remote sites	1	$11,000	$11,000
Portable receivers	2	$4,000	$8,000
Tagging Equipment			$200
Radio tags	100	$200	$20,000
Vendor Field support			$5,000
Computer	1		$2,500
Field supplies			$6,392
Salary			$116,206
Indirect costs			$24,219
Total			$210,517

XIII. APPENDIX: Summation of Calfed Bay-Delta Program Ecosystem Restoration Program Plan Volumes I and II Visions and Actions Related to Battle Creek Biological Resources as Affected by Facilities and Operations of PG&E Hydroelectric System and Coleman National Fish Hatchery

Volume I: Ecological Attributes of the San Francisco Bay-Delta Watershed

1. Ecological Process Visions

Central Valley Stream Temperatures

Strategic Objective Targets, and Programmatic Actions

Stage 1 Expectations

- **Page 62:**

Several stream temperature actions should be implemented immediately. There is general agreement that these actions will improve stream temperatures without having significant impacts on water supply or energy resources. Many of these actions have been recommended by DFG and by AFRP but have not been implemented because of limited financial resources. They include:

- Developing a long-term agreement with Pacific Gas and Electric Company (to provide appropriate compensation for energy losses) to monitor temperatures and provide bypass flows in the lower North Fork and South Fork segments of Battle Creek to maintain suitable temperatures for holding, spawning, and rearing habitat for spring-run and winter-run Chinook salmon and steelhead.

STATUS: Implemented through 1999 MOU and AMP for Restoration Project.

2. Species and Species Group Visions

High Priority At-risk Species

Chinook Salmon

Resource Description

Sacramento River Winter-Run ESU

- **Page 210:**

Historically, winter-run populations existed in the upper Sacramento, Pit, McCloud, and Calaveras Rivers. The spawning habitat for these stocks was primarily located in the Sierra Nevada Ecoregion (Omernik 1987). Construction of dams on these rivers in the 1940s led to the elimination of populations in the San Joaquin Basin and displaced the Sacramento River population to areas below Shasta Dam. There is also data to suggest that winter-run inhabited Battle Creek prior to its development for hydropower production.

STATUS: Common references for this information include: Yoshiama et al. 1998; Coots and Healey 1966; Painter in Kano 1997; Slater 1963; USFWS 1987; Rutter 1903

3. Species and Species Group Visions

High Priority At-risk Species

Chinook Salmon

Strategic Objectives, Targets, and Programmatic Actions

Winter-Run Chinook Salmon

Stage 1 Expectations

- **Page 217:**

The cohort replacement rate (the number of future spawners produced by each spawner) in 7-10 years should continue to exceed 1.7 (as it has in recent years), and average abundance should increase.

Battle Creek restoration should have proceeded to a point where a determination can be made regarding the benefits of re-introducing winter-run Chinook. The determination will be based on genetic conditions. The probability of extinction of winter-run Chinook will have been recalculated using assumptions regarding the establishment of an additional self-sustaining winter-run Chinook population.
STATUS: A feasibility study is to be completed by the state and federal fishery agencies in 2004 and 2005 depending on approval of Restoration Project by FERC.

4. Species and Species Group Visions
High Priority At-risk Species
Chinook Salmon
Strategic Objectives, Targets, and Programmatic Actions
Spring-Run Chinook Salmon
Stage 1 Expectations

- **Page 218:**

Better methods for estimating population sizes should be developed. Populations in Deer, Mill, and Butte creeks should remain within numbers found in streams in 1990-1998, with a cohort replacement rate greater than 1…The potential for other streams, including Battle Creek, to support runs of spring-run Chinook salmon should be evaluated. The potential for using artificial propagation as a tool to expedite re-introduction to former habitat will have been evaluated and, if deemed appropriate by the resource agencies, a propagation program should be implemented.
STATUS: Spring-run Chinook salmon are present in Battle Creek (USFWS 2001) despite of pre-Restoration Project conditions.

5. Species and Species Group Visions
High Priority At-risk Species
Steelhead Trout

- **Page 224:**

The Central Valley ESU comprises the Sacramento River and its tributaries and the San Joaquin River and its tributaries downstream of the confluence with the Merced River (including the Merced River). Recent data from genetic studies show that samples of steelhead from Deer and Mill creeks, the Stanislaus River, Coleman National Fish Hatchery on Battle Creek, and Feather River Fish Hatchery are well differentiated from all other samples of steelhead from California (Busby et al. 1996; NMFS 1997).
STATUS: Steelhead are present in Battle Creek (USFWS 2001) despite of pre-Restoration Project conditions. Genetic sampling of Battle Creek steelhead is being conducted.

6. Species and Species Group Visions
High Priority At-risk Species
Steelhead Trout
Stage 1 Expectations

- **Page 228:**

Central Valley steelhead numbers should not fall lower than they have been in the 1990s. Ongoing efforts to provide passage at impassable dams on key tributaries such as Battle, Clear, and Butte creeks should be accelerated. Water operations should provide temperatures adequate for summer rearing in reaches below the major reservoirs…
STATUS: Restoration Project proposal includes modernization of fish passage facilities and removal of certain dams.

7. Species and Species Group Visions
High Priority At-risk Species
Steelhead Trout
Strategic Objectives, Targets, and Programmatic Actions

Other Issues and Information Needs

Instream Flow Needs and Temperature Control Action

STATUS: Restoration Project proposal includes dramatic improvements in stream flow and consequent improvements in water temperature regime.

8. Species and Species Group Visions

High Priority At-risk Species

Steelhead Trout

Stage 1 Expectations

Restoration of Access to Historical Habitat Presently Blocked by Dams

Other Issues and Information Needs

Restoration of Access to Historical Habitat Presently Blocked by Dams

Action

- **Page 233:**

The …Battle …creeks are locations at which evaluating opportunities to provide passage above existing barriers is most needed. Evaluation of habitat capacity above barriers is an essential first step, followed by an engineering feasibility study (Meral and Moyle 1998).
STATUS: Restoration Project proposal includes improvements in stream flows to minimize natural passage barriers. Modernization of fish passage facilities and removal of certain dams would further reduce passage barriers. Habitat capacity has been verified (Kondolf and Katzel 1989).

9. Visions for Reducing or Eliminating Stressors

Dams and Other Structures

Issues and Opportunities

Opportunities for Rivers

- **Page 433:**

Remove barriers to anadromous fish migration where feasible. Significant progress has been made in recent years to improve salmon passage on several spawning streams (e.g., Butte Creek, Battle Creek) by removing barriers, consolidating diversion weirs, or constructing state-of-the-art fish passage structures. Existing and potential spawning areas in the ERP focus area that are not obstructed by major reservoir dams, but are currently obstructed by other barriers, should be identified and action taken to restore anadromous fish spawning upstream (Strategic Plan 1999).
STATUS: The fish ladder at the CNFH barrier weir was modernized in 1990 and will be further improved in 2005. The upper watershed is being addressed with the Restoration Project proposal.

10. Visions for Reducing or Eliminating Stressors

Predation and Competition

Stressor Description

Predation and Competition with Hatchery-Reared Fish

- **Page 497:**

Chinook salmon and steelhead artificially produced at and released from hatcheries may compete with (or displace) their naturally produced counterparts for food or habitat in the river, estuary, or open ocean. The major source of competition from hatchery salmonids in the upper Sacramento River would be releases from the Coleman National Fish Hatchery on Battle Creek. The extent of competition between naturally produced Chinook and releases from other hatcheries is of particular concern. The extent of this competition is unknown but is believed to be low. The size differences between the various Chinook salmon stocks may also result in segregation according to size-dependent habitat preferences because juvenile Chinook salmon and steelhead move to faster and deeper waters as they grow and do not compete with fry (Everest and Chapman 1972).

STATUS: The USBR and USFWS are committed to undertaking adaptive management for CNFH. Predation and competition are two areas of scientific uncertainty for which diagnostic studies have been recommended. USBR is currently seeking funding for these and other diagnostic studies.

11. Visions for Reducing or Elimination Stressors

Fish and Wildlife Harvest

Vision

- **Page 516:**

The vision for steelhead trout is to support harvest strategies that fully protect naturally spawning stocks while redirecting harvest to hatchery-produced stocks. This will require a marking program similar to the mass-marking program proposed for Chinook salmon, except the number of fish to mark would be lower. In this vision, adult steelhead harvest would be directed to steelhead produced at Coleman National Fish Hatchery on Battle Creek, Feather River Hatchery on the Feather River, Nimbus Hatchery on the American River, and Mokelumne River Fish Installation on the Mokelumne River. Harvest of these stocks would also occur on the mainstem of the Sacramento River.

STATUS: No changes in regulations.

12. Visions for Reducing or Elimination Stressors

Artificial Fish

Propagation

Stressor Description

- **Page 520:**

Central Valley Salmon and Steelhead Production Hatcheries and the Average Annual Production of Chinook Salmon and Steelhead:

Facility & Period of Record	Location	Fall	Spring	Late-Fall	Winter	Steelhead
Coleman Nat'l Fish Hatchery	Battle Creek	14,941,000	N.P.	639,000	26,000	814,000

N.P. = not produced

STATUS: Winter-run Chinook salmon are no longer produced at CNFH. These fish are now produced at Livingston Stone National Fish Hatchery located below Shasta Dam.

Volume II: Ecological Management Zone Visions

1. Population Targets and Programmatic Actions for Species and Species Groups

Species Population Targets and Programmatic Actions

Sacramento Winter-Run Chinook

Programmatic Action

- **Page 20:**

Additional programmatic actions that will contribute to the recovery of winter-run Chinook salmon are proposed for the Suisun Marsh/North San Francisco Bay, and Yolo Basin Ecological Management Zones. Programmatic actions proposed for Battle Creek in the North Sacramento Valley Ecological Management Zone have the potential to allow the future establishment of an addition of population of winter-run Chinook salmon.

STATUS: The National Marine Fisheries Service is currently developing a multi-species recovery plan that will develop the procedure for winter-run Chinook salmon recovery in Battle Creek.

2. Population Targets and Programmatic Actions for Species and Species Groups

Species Population Targets and Programmatic Actions

Steelhead Trout

- **Page 24:**

Population Target: Increase naturally spawning population number and sizes sufficient to maintain population resiliency and to allow meta-population persistence through periods of adverse climatic and ecological conditions. This would entail, at a minimum, restoring and maintaining viable populations in the upper Sacramento, Feather, Yuba, American, Mokelumne, Stanislaus, Tuolumne, and Merced rivers, and Battle, Clear, Big Chico, Butte, Antelope, Mill and Deer creeks.

Rationale: The Central Valley steelhead ESU encompasses the Sacramento River and its tributaries and the San Joaquin River and its tributaries downstream of the confluence with the Merced River (including the Merced River). Recent data from genetic studies show that samples of steelhead from Deer and Mill creeks, the Stanislaus River, Coleman National Fish Hatchery on Battle Creek, and Feather River Hatchery are well differentiated from all other samples from California (Busby et al. 1996; NMFS 1997).

3. Sacramento River Ecological Management Zone

Description of the Management Zone

- **Page 156:**

… Competition is primarily between naturally and hatchery produced fish and is typically for food and rearing area. The extent of adverse effects of the interaction between hatchery and natural fish has not been adequately investigated in the Central Valley, although Hallock (1987) reported that yearling steelhead released into Battle Creek consumed large numbers of naturally produced Chinook salmon fry.
STATUS: Yearling steelhead are no longer released in Battle Creek.

4. Sacramento River Ecological Management Zone

Description of Ecological Management Units

Keswick Dam to Red Bluff Diversion Dam Ecological Management Unit

5. Sacramento River Ecological Management Zone

Visions for Species

Steelhead Trout

- **Page 169:**

The Central Valley steelhead ESU encompasses the Sacramento and San Joaquin Rivers and their tributaries. Recent data from genetic studies show that samples of steelhead from Deer and Mill Creeks and Coleman National Fish Hatchery on Battle Creek are well differentiated from all other samples of steelhead from California.
STATUS: No change.

6. Sacramento River Ecological Management Zone

Integration with other Restoration Programs

Central Valley Project Improvement Act

- **Page 172:**
  - Implement Coleman National Fish Hatchery Plan and modify Keswick Dam Fish Trap.

STATUS: CNFH Plan is partially implemented and Keswick Dam fish trap has been completed.

7. Sacramento River Ecological Management Zone

Restoration Targets and Programmatic Actions

Artificial Fish Propagation

Programmatic Action 4B
Rationale

- **Page 187:**

Recent returns to CNFH of fall-run Chinook salmon seem to indicate that the hatchery is heavily supporting the entire fall-run population, particularly in Battle Creek, all of which probably originated from CNFH. A recent estimate for the rest of the Sacramento River above RBDD, excluding Battle Creek, was only 40,000 fish, which may also have been heavily supported by CNFH production.

STATUS: No substantive change.

9. North Sacramento Valley Ecological Management Zone

Description of the Management Zone

- **Pages 190-191:**

… Small hydropower projects, water diversion and water diversion structures constrain ecological processes and functions on Battle Creek. Past and current operation of Coleman National Fish Hatchery on the lower section of the creek further impairs opportunities to improve the distributions of wild salmon and steelhead stocks.

STATUS:

10. North Sacramento Valley Ecological Management Zone

Description of the Ecological Management Unit

Battle Creek Ecological Management Unit

Pages 196-199

11. North Sacramento Valley Ecological Management Zone

Vision for the Ecological Management Zone

Visions for the Ecological Management Units

Battle Creek Ecological Management Unit

- **Page 201:**

The vision of the Battle Creek Ecological Management Unit includes support for a local watershed conservancy and developing and implementing a comprehensive watershed management plan, increasing flows, improving the water supply to Coleman National Fish Hatchery, removing diversion dams or installing new ladders, and installing positive-barrier fish screens to protect juvenile Chinook salmon and steelhead.

STATUS: The Battle Creek Watershed Conservancy has been an active participant in Battle Creek restoration planning in recent years. The BCWC has developed a watershed strategy and has nearly completed a watershed assessment. The BCWC has been funded to develop a monitoring program that will build on the watershed strategy.

Installing water management operations and installing positive-barrier fish screens will provide large benefits to many aspects of the ecological process and fish and wildlife in the watershed. ERPP also envisions that Battle Creek will provide much-needed habitat for steelhead trout and spring-run Chinook salmon, in addition to maintaining its existing importance to fall- and late-fall run Chinook.

STATUS: Instream flows have been increased on an interim basis until the Restoration Project is implemented.

12. North Sacramento Valley Ecological Management Zone

Restoration Targets and Programmatic Action

Habitats

Programmatic Action 1C

- **Page 209:**

Cooperatively negotiate long-term agreements with local landowners to maintain and restore riparian communities along the lower reaches of …Battle creeks.

STATUS: Numerous conservation easements have been negotiated with local landowners by The Nature Conservancy.

13. North Sacramento Valley Ecological Management Zone

Restoration Targets and Programmatic Action

Eliminating or Reducing Stressors

Water Diversions

- **Pages 209-210:**

Target 1: Reduce or eliminate conflicts between the diversion of water and Chinook salmon and steelhead populations at all diversion sites on Battle Creek.

Programmatic Action 1A: Develop a cooperative approach to improve conditions for anadromous fish in Battle Creek by installing fish screens at diversions on the North Fork, three diversions on the South Fork, and one diversion on the mainstem, or acquire water rights to eliminate the need for diversion and screening.

STATUS: Environmental documentation is underway for the Restoration Project.

Programmatic Action 1B: Improve the survival of adult salmon and steelhead in Battle Creek by installing a rack at the head of Grover Diversion Canal to prevent straying.

STATUS: This barrier has been installed.

Rationale: Diversion, storage, and release of water in the Clear and Battle Creek watersheds directly affect fish and other aquatic organisms and indirectly affect habitat, foodweb production, and species abundance and distribution… In both Clear and Battle Creeks, water diversion and water diversion structures have caused direct mortality by removing juvenile fish from the population…

Coleman National Fish Hatchery receives its water supply directly from Battle Creek. Because of past incidences of disease at the hatchery, adult salmon and steelhead were blocked from ascending the creek to prevent disease contamination of the hatchery water supply. Restoring naturally spawning fish in the upper watershed will be limited until water can be supplied to the hatchery in a manner that will not contribute to disease outbreaks.

STATUS: An ozone water treatment plant has been installed and is operating as planned. Upstream passage of anadromous fish has been increased.

14. North Sacramento Valley Ecological Management Zone

Restoration Targets and Programmatic Action

Eliminating or Reducing Stressors

Dams and Other Structures

- **Pages 210-211:**

Target 5: Reduce or eliminate conflicts in Battle Creek that require excluding anadromous fish from the upper section to protect the Coleman National Fish Hatchery water supply.

Programmatic Action 5A: Develop an alternative or disease-free water supply for Coleman National Fish Hatchery to allow naturally spawning salmon and steelhead access to the full 41-mile reach of Battle Creek above the Coleman National Fish Hatchery Weir.

STATUS: An ozone water treatment plant has been installed and is operating as planned.

Rationale: Dams and their associated reservoirs block fish movement, alter water quality, remove fish and wildlife habitat, and alter hydrological and sediment processes. Fish passage in the North Sacramento Valley Ecological Management Zone is impaired in Clear, Cow, Bear, and Battle Creeks by a variety of permanent and seasonal dams used to divert water for irrigation or power production. Other human-made structures may block fish movement or provide habitat or opportunities for predatory fish and wildlife, which could be detrimental to fish species of special concern, such as spring-run Chinook salmon and steelhead, as well as the other stocks of Chinook salmon. Improve fish habitat will allow

anadromous fish to reach the habitat they require to oversummer or to spawn in good health, which will increase their chances of successfully spawning…
STATUS: Negotiations are being conducted with two operators of seasonal diversion dams in Battle Creek.

15. North Sacramento Valley Ecological Management Zone
Restoration Targets and Programmatic Action
Eliminating or Reducing Stressors
Artificial Propagation of Fish

- **Page 212:**

Target 1: Minimize the likelihood that hatchery-reared salmon and steelhead produced in the Coleman National Fish Hatchery will stray into non-natal streams, thereby protecting naturally produced salmon and steelhead.

Programmatic Action 1: Develop a cooperative program to evaluate the benefits of stocking hatchery-reared salmon and steelhead in the Sacramento River and Battle Creek. Stocking may be reduced in years when natural production is high.

Rationale: In watersheds such as the Sacramento River and Battle Creek, where dams and habitat degradation have limited natural spawning, hatchery supplementation may be necessary. This would sustain fishery harvest at former levels and maintain a wild or naturally spawning population during adverse conditions, such as droughts. Hatchery augmentation, however, should be limited so as not to inhibit recovery and maintenance of wild populations. Hatchery-reared salmon and steelhead may directly compete with and prey on wild salmon and steelhead… Because of the extent of development on the Sacramento River and Battle Creek, Chinook salmon and steelhead stocking may be necessary to rebuild and maintain stocks to sustain sport and commercial fisheries.

16. Butte Basin Ecological Management Zone
Restoration Targets and Programmatic Actions
Reducing or Eliminating Stressors
Artificial Propagation of Fish

- **Pages 266-267:**

Target 1: Minimize the likelihood that hatchery-reared salmon and steelhead produced in the Coleman National Fish Hatchery will stray into non-natal streams to protect naturally produced salmon and steelhead.

Programmatic Action 1: Develop a cooperative program to evaluate the benefits of stocking hatchery-reared salmon and steelhead in the Sacramento River and Battle Creek. Stocking may be reduced in years when natural production is high.
STATUS: The USBR and USFWS are committed to undertaking adaptive management for CNFH. Hatchery production and stocking are two areas of scientific uncertainty for which diagnostic studies have been recommended. USBR is currently seeking funding for these and other diagnostic studies.

Rationale: Hatchery augmentation should be limited to protect recovery and maintenance of wild populations. Hatchery-reared salmon and steelhead may directly compete with and prey on wild salmon and steelhead… Because of the extent of development on the Sacramento River and Battle Creek, stocking Chinook salmon and steelhead may be necessary to rebuild and maintain stocks to support sport and commercial fisheries.

Literature Cited

Coots, M. and T. Healey. 1966. Pacific Gas and Electric Company's Battle Creek System Power Project, Minor Part License Number 1121. California Department of Fish and Game File Report. 32 pp.

Kano, R. M. and R. Reavis. 1997. Annual Report Chinook Salmon Spawner Stocks in California's Central Valley, 1987; Battle Creek by Richard Painter. Page 10. Department of Fish and Game Inland Fisheries Division Administrative Report No. 97-4.

Rutter, C. 1903. Natural history of the quinnat salmon: A report on investigations in the Sacramento River, 1896-1901: Extracted from U.S. Fish Commission Bulletin for 1902. Pages 86 to 131, Plates 10 to 18.

Slater, D. W. 1963. Winter-run chinook salmon in the Sacramento River California with notes on water temperature requirements at spawning. U.S. Fish and Wildlife Service Spec. Sci. Rept. 461, 9pp.

USFWS (U.S. Fish and Wildlife Service). 1987. An analysis of the effectiveness of the mitigation plan for Shasta and Keswick Dams. 36 pp.

Yoshiyama, R.M., F.W. Fisher, and P.B. Moyle. 1998. Historical abundance and decline of chinook salmon in the Central Valley region of California. North American Journal of Fisheries Management. 18:487-521.