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
Sausalito, California

April 1999

Cover Photo

Coleman National Fish Hatchery is located on the banks of lower Battle Creek. Operations of the Coleman National Fish Hatchery and habitat conditions in lower Battle Creek need to be made compatible with restoration programs initiated in the middle portions of the Battle Creek watershed.

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

Michael B. Ward
William M. Kier

Kier Associates
Sausalito, California

April 1999

ACKNOWLEDGMENTS

The novel and untested situations that are likely to be encountered by restoration of Battle Creek salmonids may lead to management scenarios that are hard to predict and that have not been documented in existing literature. Therefore, Kier Associates relied heavily on the expert opinions of some of the country's leading salmon scientists in identifying and assessing challenges that are likely to be encountered. We thank the following individuals for their generous contributions to this report, and remind the readers that we, not these experts, are responsible for how their opinions were documented in this report:

- Dr. Michael Banks, University of California at Davis, Bodega Marine Lab, Bodega, California
- Howard Fuss, Washington Department of Fish and Wildlife, Olympia, Washington
- Mark Gard, USFWS, Sacramento, California
- Scott Hamelberg, USFWS, Red Bluff, California
- Dr. Dennis Hedgecock, University of California at Davis, Bodega Marine Lab, Bodega, California
- Dr. Ron Hedrick, University of California, Davis, California
- Dr. Ted Meyer, Alaska Department of Fish and Game, Juneau, Alaska
- Tom Nelson, USFWS-CNFH, Anderson, California.
- Dr. Gabrielle Nevitt, University of California, Davis, California
- Dr. Tom Quinn, University of Washington, Seattle, Washington
- Harry Rectenwald, CDFG, Redding, California
- Steve Roberts, Washington Department of Fish and Wildlife, Spokane, Washington
- Jim Smith, USFWS, Red Bluff, California
- Geraldine Vander Haegen, Washington Department of Fish and Wildlife, Olympia, Washington
- Jason Watters, University of California, Davis, California

EXECUTIVE SUMMARY

This document is an addendum to the Battle Creek Salmon and Steelhead Restoration Plan (Restoration Plan, Ward and Kier 1999) which was prepared under the direction of the Battle Creek Working Group (BCWG; Table 1). The Restoration Plan proposes significant improvement of salmon and steelhead habitat in the reaches of Battle Creek affected by the Battle Creek Hydroelectric Project, which is owned and operated by the Pacific Gas and Electric Company. The hydroelectric project reaches are upstream of the Coleman National Fish Hatchery (CNFH; Figure 1). The lower reaches of Battle Creek were not, however, addressed in the Restoration Plan. To the extent that lower Battle Creek conditions, including CNFH operations, may impinge upon the success of the upstream restoration, it is necessary to address such conditions as an essential element of the overall restoration program. Consideration of lower Battle Creek conditions is, then, the purpose of this addendum report.

Current operations at CNFH would be likely to impede the restoration of salmon and steelhead in several ways. Operation of the fish ladder on the CNFH barrier dam may deny access to restored habitats at critical times for steelhead and all four stocks of chinook salmon. Broodstock selection at CNFH may have led to hybridization between fall-run and spring-run chinook and possibly between fall-run and late-fall-run. Excess number of hatchery-produced fall-run chinook may be overwhelming the carrying capacity of lower Battle Creek. This Compatibility Plan details these and several other lower-reach issues that the BCWG can address in the months ahead to assure the success of the substantial public and private investment in the upstream restoration effort.

This Compatibility Plan also introduces a decision matrix designed to assist the BCWG in addressing these complicated issues. A preliminary suite of possible alternative management scenarios is introduced. These alternatives are juxtaposed with policy, fish population, and fish habitat issues in a matrix that should be completed by a future, collaborative group of stakeholders and agency experts. The result of that process would be a revised management plan for the operations of CNFH and the management of habitat in lower Battle Creek that would maximize compatibility with fish restoration programs.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

THE NEED FOR COMPATIBILTY IN RESTORATION PLANNING

This document (referred to here as the "Compatibility Plan") serves as an addendum to the Battle Creek Salmon and Steelhead Restoration Plan (referred to as the "Restoration Plan"; Ward and Kier 1999) which documents past restoration efforts within the Battle Creek watershed and which provides recommendations for future efforts to restore chinook salmon (*Oncorhynchus tschawytscha*) and steelhead (*O. mykiss*) populations using ecosystem-based principles. This document, as well as the restoration plan, were developed under the technical guidance of the stakeholder-based Battle Creek Working Group (BCWG; Table 1).

The Restoration Plan focused on the middle reaches of Battle Creek, the area of hydroelectric development (Figure 1). It did not deal with the stream's lower reaches, nor the need for insuring that operations of the Coleman National Fish Hatchery (CNFH) are compatible with the upstream restoration program. Now that specific actions to restore habitat to anadromous salmonids in Battle Creek upstream of CNFH have been agreed to by the resource agencies and Pacific Gas and Electric (PG&E), the owner of the Battle Creek Hydroelectric Project, a closer examination of the operations of CNFH and the portion of Battle Creek most impacted by CNFH operations is necessary to insure that restoration of populations of anadromous salmonids in Battle Creek will not be impeded by hatchery operations or deficiencies in the habitat of the lower watershed.

This Compatibility Plan is divided into three sections. The first section, "The Need for Compatibility In Restoration Planning," explains existing conditions in Battle Creek and the management paradigms under which compatibility planning should take place. These paradigms include significant developments in the restoration of salmon and steelhead habitat in the Battle Creek watershed upstream of CNFH that have occurred since completion of the Restoration Plan; the importance of coordinating CNFH operations with restoration planning for the Battle Creek watershed and the need to isolate CNFH operations from Battle Creek's aquatic ecosystems while not impeding its mitigation obligations; and the condition of habitat in lower Battle Creek and the history of its management. The next section, the "Technical Plan," builds on the first section by discussing those aspects of CNFH operations which need to be coordinated with the upstream restoration; introducing alternative actions that may alleviate areas of concern, and proposing a decision-making framework for assessing and prioritizing restoration actions. The Technical Plan also lists existing conditions, limiting factors, ecosystem functions and restoration objectives for lower Battle Creek. Finally, the last section details "Recommendations" for the operation of CNFH and the habitat of lower Battle Creek. Many of these recommendations are phrased as "suggested evaluations" because restored habitats and populations are novel and pose new scientific challenges for the operation of CNFH and management of lower Battle Creek.

Table 1. A partial list of member organizations and agencies that comprised the Battle Creek Working Group and acronyms used in this report.

Battle Creek Watershed Conservancy (BCWC)
Battle Creek Watershed Project (BCWP)
California Department of Fish and Game (CDFG)
California Department of Water Resources (CDWR)
Central Valley Project Water Association (CVPWA)
United States Forest Service - Lassen National Forest (USFS - LNF)
Mount Lassen Trout Farms (MLTF)
Metropolitan Water District of Southern California (MWDSC)
National Marine Fisheries Service (NMFS)
Pacific Coast Federation of Fishermen's Assn. (PCFFA)
Pacific Gas and Electric Company (PG&E)
Tehama County Resource Conservation District (TCRCD)
The Nature Conservancy (TNC)
United States Bureau of Land Management (BLM)
United States Bureau of Reclamation (USBR)
United States Fish and Wildlife Service (USFWS)
Western Area Power Administration (WAPA)
Western Shasta Resource Conservation District (WSRCD)

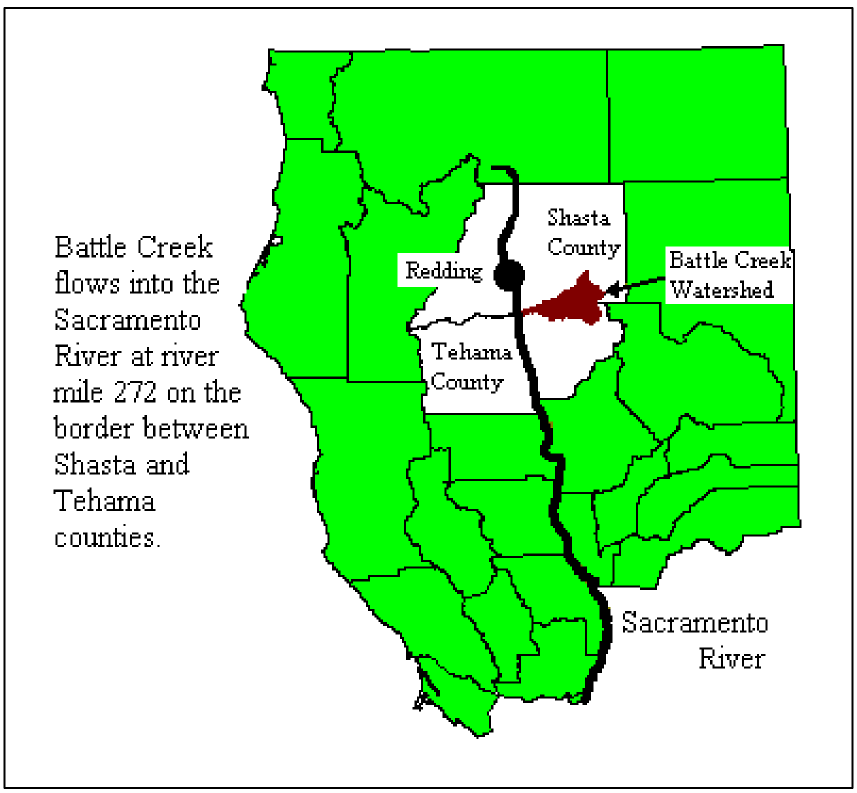

Figure 1. The location of the Battle Creek watershed in relation to the counties of Northern California.

Present Restoration Efforts

On February 16, 1999, the California Department of Fish and Game (CDFG), U. S. Fish and Wildlife Service (USFWS), U. S. Bureau of Reclamation (USBR), National Marine Fisheries Service (NMFS), and PG&E reached an “Agreement in Principle” regarding future actions to be taken to restore habitat for chinook salmon and steelhead in many of the upstream reaches of Battle Creek affected by PG&E’s hydroelectric project (Table 2). This Agreement in Principle is subject further to the preparation of a Memorandum of Understanding (MOU) between the resource agencies and PG&E, as well as approval by the federal Energy Regulatory Commission (FERC) through the license amendment process. Within the FERC license amendment process, the proposed MOU will be subject to public and scientific scrutiny particularly concerning its compliance with the National Environmental Policy Act (NEPA) and California Environmental Quality Act (CEQA).

In addition to restoration actions outlined in the Agreement in Principle, efforts are underway to seek funds for changes to the CNFH barrier dam, including improvements to the fish ladder and changes in the barrier characteristics of this dam. Although a proposal to CALFED (the State-federal organization supporting ecosystem restoration efforts in California’s Central Valley and San Francisco Bay-Delta estuary) submitted in January 1999 was declined because it needed more clarification, CALFED did invite a resubmission of the proposal for the April 1999 deadline for competitive funding. Central Valley Project Improvement Act (CVPIA) funds have also been identified as a mechanism for modifying CNFH barrier dam to better assist the rebuilding of Battle Creek’s natural salmon and steelhead populations.

These recent developments, when implemented, will likely lead to dramatic and important changes in fish populations within the Battle Creek watershed. A total of 47.5 miles of habitat capable of producing steelhead and four races of chinook salmon will be available in Battle Creek, including 42.4 miles that was previously unavailable or significantly degraded by the Battle Creek Hydroelectric Project (Ward and Kier 1999). This restored habitat is generally of excellent quality and should provide optimum conditions mimicking those present prior to Euro-American settlement. Rough estimates of the number of salmon and steelhead that may be produced in the fully restored Battle Creek watershed are on the order of 20,000 fish (Ward and Kier 1999). But more importantly, populations of endangered or threatened salmonids, including winter- and spring-run chinook salmon and steelhead, will be reestablished in a stable and protected stream environment that could provide the difference between survival and extinction.

The implementation of restoration principles recently agreed to by the resource agencies and PG&E are expected to take place over the next three years. This idealized schedule might proceed somewhat as follows:

- March 10, 1999 – Public Workshop in Manton
- March 11, 1999 – Public Workshop in Red Bluff
- April 16, 1999 – CALFED Deadline for MOU
- Spring/Summer 1999 – Begin environmental compliance processes including NEPA/CEQA Workshops, Begin Engineering Design Work
- Fall/Winter 1999 – Continue environmental compliance processes including NEPA/CEQA Workshops

- 1999 – Permitting, Continue Engineering Design Work
- 2000 – Finalize Engineering Design Work, Initiate Construction
- 2001 – Complete Construction

Of course, this scheduling and the details of final restoration actions are subject to change, especially due to the uncertainties inherent in agency implementation and the public processes associated with environmental compliance. The environmental compliance processes should insure that benefits from the final suite of restoration actions equal or exceed those that would accrue from the currently proposed suite of restoration actions. This suggests that significant improvements in Battle Creek habitat conditions will occur in the near future.

Decisions regarding the restoration of habitat in the portion of the Battle Creek watershed affected by hydroelectric project operations were based, in part, on principles that the responsible State and federal resources agencies consider essential for salmon and steelhead restoration in Battle Creek (Table 5). These principles will also be used to guide the development of the recommendations for restoration in lower Battle Creek addressed in this report.

CNFH Operations Should Be Compatible With Restoration

The Role of the Hatchery and its Relationship to the Watershed

The purpose of the CNFH, operated by the USFWS, has been to mitigate for salmon spawning habitat in the Sacramento River and its tributaries that were blocked by the construction of Shasta Dam in the 1940s (Black 1999; USFWS 1999a). Similarly, earlier hatcheries at this site were operated for the purpose of maintaining and enhancing salmon populations in the Sacramento River (SBFC 1896). Current efforts are underway within the USFWS to determine whether CNFH should or will play a role in mitigating for portions of the Central Valley Project (CVP) other than Shasta Dam (e.g. Red Bluff Diversion Dam) and will be documented in a forthcoming evaluation of CNFH (Scott Hamelberg, USFWS, Red Bluff, California, pers. comm.). In discussing mitigation requirements at Red Bluff Diversion Dam (RBDD), however, USFWS (1998a) states that current operations of RBDD eliminate the need for fall-run chinook compensation, suggesting that CNFH will not be playing a role in mitigating RBDD.

CNFH is the only federally operated hatchery in California (USFWS 1996) and it is the main surviving component of the Shasta Salmon Salvage Plan (Needham 1943; Black 1999). The contribution of CNFH-produced fish to the Pacific Ocean salmon fishery is important (USFWS 1999c), about 20 percent of the catch. However, “It doesn’t matter what Coleman’s contribution is if the fishermen don’t have access to those fish because of ESA constraints. That’s why we are so anxious for the speedy and successful restoration of natural stocks in Battle Creek and the Sacramento River” (Zeke Grader, Pacific Coast Federation of Fishermen’s Associations, San Francisco, California, pers. comm.). Furthermore, there is hope that CNFH’s contributions to the fishery will improve in the future as ongoing restoration activities in the Sacramento River and the Sacramento-San Joaquin Delta help outmigration and survival of all salmon including CNFH fish (Zeke Grader, Pacific Coast Federation of Fishermen’s Associations, San Francisco, California, pers. comm.).

CNFH was never intended to maintain, enhance, or supplement fish populations in Battle Creek (Black 1999). Habitat in Battle Creek has not been directly impacted by the CVP, though Battle Creek fish populations may suffer from CVP operations downstream of Battle Creek (e.g. at the Red Bluff Diversion Dam or federal pumping plant in the Sacramento-San Joaquin Delta) or within Battle Creek through the operation of the barrier dam at CNFH, which is, as a component of a CVP mitigation facility, arguably a component of the CVP.

The primary reason that CNFH was placed on Battle Creek, rather than in the vicinity of Shasta Dam, which would have been more logical siting for a mitigation hatchery, was because of concerns related to inadequate water quality below Shasta Dam. These concerns lead to the rejection of three alternative proposals (Black 1999). In fact, for most of the history of CNFH, habitat and fish populations within Battle Creek upstream of CNFH were dismissed or even intentionally suppressed (see the history of the CNFH Barrier Dam in Ward and Kier 1999).

The USFWS (1994) prepared a comprehensive ecosystem- and watershed-based conservation, restoration, and enhancement program, that included an innovative propagation program that supports native species restoration, endangered species recovery, federal mitigation responsibilities, commercial and recreational fishing, monitoring and assessment programs. Portions of this “Action Plan” that seem especially relevant to CNFH and Battle Creek include high priority actions such as:

- Develop national policies on fishery conservation, restoration, and mitigation that protect natural habitats and wild populations, restore or maintain aquatic ecosystem diversity, ensure consideration of aquatic resources in development project planning, and include fishery resource evaluations as a critical part of mitigation follow-up studies.
- Ensure that production of hatchery fish and associated management are based on integrated principles of conservation genetics and ecology.
- Develop Aquatic Resource Management Plans that outline specific strategies and objectives that consider genetic, ecological, and economic characteristics of fishery resources, especially wild populations and those in decline or in threat of decline.
- Design and implement innovative fishery technology development activities to support conservation and restoration of aquatic ecosystems.
- Establish fish health programs and protocols to protect wild and hatchery populations from diseases. Develop technologies and procedures to minimize risk of pathogen transfer to avoid or minimize epizootic outbreaks.

Stakeholders and agencies interested in the restoration of Battle Creek fisheries have been working collaboratively to modify facilities at CNFH (see Ward and Kier 1999 for details) and a number of these facility modifications will act to isolate CNFH operations from Battle Creek. For example, an ozone treatment plant is currently being installed to keep fish pathogens out of the hatchery water supply which will effectively maintain two separate fall-run chinook populations, an IHN-infected natural population and a INH-free hatchery population. Water supply intakes to the CNFH are being improved with fish screens and plans for an interim tailrace barrier at the Coleman Powerhouse are being developed (USBR 1998). Proposals have been made to modify the CNFH barrier dam, in part to keep hatchery-produced fall-run fish out of the main portion of the Battle Creek watershed, and also to modify the fish ladder at the barrier dam so that it will not impede salmon migrating into the watershed at high flows (USFWS 1999b).

Table 2. Elements of the Agreement in Principle jointly developed by PG&E and the resources agencies including CDFG, USFWS, USBR, and NMFS, on February 16, 1999.

Facilities: Decommission Wildcat, Coleman, Soap Creek, Lower Ripley and South Diversion Dams and associated water conveyance facilities that will no longer be in service; screen and ladder N. Battle Creek Feeder, Inskip and Eagle Canyon Diversion Dams; install tailrace connectors and water bypass facilities at Inskip and South Powerhouses. PG&E, or its successor(s) (Project Owner) agrees to support installation of the connector at South Powerhouse concurrent with, or prior to, the Inskip Diversion Dam Fish Screen.
Flows: See attached Tables 1 and 2 which list "Prescribed Instream Flow Releases." The Resource Agencies will meet and confer with Project Owner before determining flow ramping provisions for returning facilities to service following shutdowns.
Economic Variables: Adopt 12/98 CEC energy forecast & revise discount rate to 9.17%. Include all costs of proposal: O&M impacts, license amendment, all study costs associated with decommissioning, Facility Monitoring[1] and Biological/Environmental Monitoring[2], a $3 million Water Acquisition Fund, and a $3 million Adaptive Management Fund (See Table 3 "Total Project Cost" and Table 4 "Summary of Assumptions").
Water Acquisition Fund Protocol: Water Acquisition Fund administered by Resource Agencies following consultation with appropriate interested parties. Water Acquisition Fund shall be placed in an escrow account and used solely for purposes of purchasing additional flows if the Resource Agencies determine such flows are necessary during the first 10 years of initiation of instream flow changes listed in Tables 1 and 2. During this first ten year period, payment to the Project Owner for agreed-upon instream flow changes will be made annually. After the first January 1st following the expiration of the first 10 years of instream flow changes listed in Tables 1 and 2, all uncommitted funds would revert to CALFED; funds for instream flow changes agreed upon before the subject January 1st which remain in effect after the subject January 1st will be paid to the Project Owner in one lump-sum payment based on the net present value of foregone energy for the period inclusive of the realized increased flows and expiration date of the current FERC license. Protocols to determine appropriate flow changes for anadromous fish to be funded with the $3 million Water Acquisition Fund will be developed in which both Resource Agencies and Project Owner make the determination through a consensus process. If consensus is not achieved, Project Owner and Resource Agencies (collectively) will each 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 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 45 days from such date of determination that consensus has not been achieved. These times may be extended by mutual agreement of the Resource Agencies and Project Owner. If consensus through mediation is still not achieved, the Resource Agencies and Project Owner reserve their right to petition FERC to resolve the subject action. Resource Agencies and Project Owner will be responsible for assuming their respective costs for FERC process. Interim flows will be provided by Project Owner until there is either consensus or FERC approval of the additional flows determined to be necessary by Resource Agencies. Water Acquisition Funds shall be used to implement consensually-agreed to or the FERC-approved actions, and interim actions which have been taken pending FERC action.

[1] FACILITY MONITORING includes verification that agreed-upon instream flows including ramping limitations are met, verify and document fish screen and ladder facilities continue to function as designed, i.e., report to FERC of screen and ladder outages, alarms, reasons for operational deviations, verify no gaps exceeding design criteria exist in the fish screen structure, perform periodic inspections to verify screen is being properly maintained and site conditions have not significantly changed, having the Owner's operator note any fish stacking below the fish ladders and fish passing up the ladder.

[2] BIOLOGICAL/ENVIRONMENTAL MONITORING includes anadromous fish survey (i.e., abundance, distribution and timing of adult and juvenile fish), water quality/meteorology, barrier formation, long-term fish passage at fish passage facilities.

Table 2 continued. Elements of the Agreement in Principle jointly developed by PG&E and the resources agencies including CDFG, USFWS, USBR, and NMFS, on February 16, 1999.

Adaptive Management Fund Protocol: Adaptive Management Fund administered by Resource Agencies following consultation with appropriate interested parties[3]. Adaptive Management Fund shall be placed in an escrow account and used solely for Battle Creek salmon and steelhead restoration purposes directly associated with the facilities and operations of FERC Project No. 1121, i.e., instream flow changes (after exhaustion or termination of the Water Acquisition Fund), and facility modifications; all uncommitted funds will revert to the third party at the end of the current FERC license term. Protocols to determine appropriate actions that benefit anadromous fish to be funded with the $3 million Adaptive Management Fund will be developed in which both Agencies and Project Owner make the determination through a consensus process. For funding instream flow changes, the protocol would be the same as for the Water Acquisition Fund discussed above. For funding facility modifications, the protocol would be the same as for the Water Acquisition Fund discussed above with 2 exceptions: 1) no interim actions would be implemented prior to FERC action; and 2) for all FERC resolved actions, the Adaptive Management Fund would contribute a maximum of 60 percent of any resulting facility modification cost. In other words, for actions related to facility modifications, funds from the Adaptive Management Fund shall be used to implement 100% of the costs of consensually-agreed to actions but only 60% of the costs of actions submitted to FERC for resolution, the remaining 40% to be borne by the Project Owner in the latter case.
Total Cost: $50.7 million (includes $1 million CALFED-funded monitoring; additional monitoring funding to be provided by others i.e., CVPIA, CAMP, etc.)
Payment to Project Owner: $2.1 million
Resource Agency Cost Sharing: Public funding for: all screens, ladders, connectors, decommissioning, decommissioning studies, start-up and acceptance testing prior to transferring ownership and operations and maintenance responsibilities to Project Owner, construction and decommissioning over-runs, environmental permitting (i.e., all necessary environmental permitting (e.g., NEPA/CEQA), including additional FERC-required decommissioning studies), all Biological/environmental monitoring (except for Owner's limited participation and use of internal technical and fishery expertise to jointly develop Agencies' monitoring plan, assist in analyses, review results and identify potential adaptive management measures), and Water Acquisition Fund; 10% of Purchased Water Costs.
Resource Agency Contribution: $27.2 million = 54%. Includes portion of Biological/Environmental Monitoring[2]; other governmental funding sources (CVPIA, CAMP) will be used for monitoring.
Third Party Cost Sharing: Third Party funding for $3 million Adaptive Management Fund **Third Party Contribution:** $3 million = 6%

[3] An Adaptive Management Plan will be developed to contribute to the sustainability of naturally spawned anadromous salmonids and the associated ecosystem of Battle Creek affected by FERC Project No. 1121 facilities or operations. The Adaptive Management Plan will be developed by consensus. The Adaptive Management Plan will develop a broadly applicable and flexible framework for an adaptive management program specific to impacts resulting from FERC Project No. 1121 facilities or operations and will include: establishing objectives; planning for unanticipated outcomes; recognizing appropriate time frames for resource management and recovery; defining the role of assessment monitoring; developing general procedures for prioritizing expenditures of Adaptive Management Funds; and developing general procedures for modifying management approaches using new scientific data. The Adaptive Management Plan will implement specific actions to protect, restore, enhance, and monitor salmonids and salmonid habitat, at FERC Project No. 1121, to guard against straying and to ensure that salmon and steelhead fully access and utilize available habitat in a manner that benefits all life stages and thereby maximizes natural production, fully utilizing ecosystem carrying capacity. The Adaptive Management Plan may also include measures to minimize impacts of Project operations upon life stages of salmon and steelhead.

Table 2 continued. Elements of the Agreement in Principle jointly developed by PG&E and the resources agencies including CDFG, USFWS, USBR, and NMFS, on February 16, 1999.

Project Owner Cost Sharing: Project Owner funding for: 90**%** of Purchased Water Costs; 100% of increased O&M, foregone power due to ramping rate requirements and periodic screen and ladder repairs, and replacements due to normal wear-and-tear and catastrophic damage. Screen and ladder modifications and replacements due to changes in design to improve biological effectiveness which meet NMFS adopted criteria will be paid from the Adaptive Management Fund; Facility Monitoring[1] to verify flows are provided as agreed, and screens and ladders continue to function as designed. Project Owner pays all internal costs associated with FERC license amendment and Facility Monitoring[1] (Biological/Environmental Monitoring[2] including overall effectiveness of modifications, fish population and distribution monitoring which is beyond Project Owner Facility Monitoring[1] requirements will be paid by CALFED. Owner shall participate in and provide limited internal technical and fishery expertise to the Agencies' Biological/Environmental Monitoring[2] program at its own cost.)
Project Owner Contribution: $20.6 million = 40% Includes limited portion of Biological/Environmental Monitoring[2]
Assurances and Requirements (to be stipulated in MOU and provided through ESA permits and FERC license): Project Owner will voluntarily reopen its FERC license through the license amendment process to enhance the Battle Creek fishery as described in the MOU and related agreements. The Resource Agencies agree to: 1) support project owner's FERC license amendment to incorporate the restoration actions described herein into FERC License No. 1121, and 2) support the position that FERC focus this license amendment on the restoration actions described herein in order to streamline the process for a FERC decision to allow Battle Creek restoration to go forward in a timely manner. No ESA assurances. Water Acquisition Fund provided by CALFED and administered by Agencies to pay for any additional future flow changes for salmon and steelhead restoration purposes directly associated with the facilities and operations of FERC Project No. 1121 pursuant to the above-mentioned protocols. Adaptive Management Fund provided by Third Party and administered by Agencies to pay for any additional future salmon and steelhead restoration purposes directly associated with the facilities and operations of FERC Project No. 1121 pursuant to the above-mentioned protocols. Water diversion rights associated with all dams to be decommissioned will be transferred to the appropriate party (CDFG, NMFS, USFWS). Based on the assumption that all PG&E water rights on the South Fork of Battle Creek have an equal priority, water rights transferred to Agencies will not be used by the Agencies to increase bypass flows above the amounts specified in the MOU, or developed pursuant to the Adaptive Management Program. If FERC License No 1121 is abandoned, then the limitation regarding transferred water rights would no longer apply. Project Owner and the Resource Agencies, or their designee, will file a Petition with the SWRCB pursuant to Water Code 1707 to preserve and enhance instream flows. Project Owner and the Resource Agencies, or their designee, agrees to support such a petition. Water associated with meeting the prescribed flow schedules below all dams screened and laddered plus Baldwin Creek will be included in the FERC license amendment in order to maintain fish and wildlife resources. Additionally, Project Owner and the Resource Agencies will execute an agreement ensuring that the currently agreed-upon bypass and ramping flows at each remaining dam, and any agreed-upon future changes to those flows, resulting from the adaptive management program developed in the MOU, will be provided by Project Owner until the end of the current FERC license and any subsequent annual licenses. This commitment to provide bypass and ramping flows may be subject to change by FERC at the expiration of the current license term in 2026. Project Owner and Resource Agencies (subject to State and federal laws) agree to support the continuation of such bypass and ramping flows, resulting from the adaptive management program developed in the MOU, and any agreed upon future changes to those flows, in any relicensing proceeding for FERC License No. 1121. The Parties agree that for the term of the license, and any subsequent annual licenses, the flows developed by the Adaptive Management Program will not be lower than those flows specified in attached Tables 1 and 2 (to be incorporated in MOU) unless agreed to by the Resource Agencies.
Screening and Laddering Requirements for N. Battle Creek Feeder, Inskip and Eagle Canyon diversions: Diversion dams would need to be equipped with NMFS/CDFG approved "fail-safe" fish screens and ladders. The diversions would require full closure during screen failure and year-round remote sensing and inspection to monitor performance.

Table 3. Summary of prescribed instream flow releases from dams in the anadromous reaches of the North and South forks of Battle Creek based on modeled biological optimums determined by the Battle Creek Working Group Biological Team

Dam	Fork	Monthly Minimum Flow (cfs) To Be Released From Dam											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Keswick	North	3[A]	3[A]	3[A]	3[A]	3[A]	3[A]	3[A]	3[A]	3[A]	3[A]	3[A]	3[A]
NBCF	North	88[F]	88[F]	88[F]	67[F]	47[F]	47[F]	47[F]	47[F]	47[F]	47[F]	47[F]	88[F]
Eagle	North	46[S]	46[S]	46[S]	46[S]	35[S]	35[S]	35[S]	35[S]	35[S]	35[S]	35[S]	46[S]
Wildcat	North	(Facility decommissioned; no instream flow requirement)											
South	South	(Facility decommissioned; no instream flow requirement)											
Inskip	South	86[P1]	86[P1]	86[P1]	61[P1]	40[P1]	40[P1]	40[P1]	40[P1]	40[P1]	40[P1]	40[P1]	86[P1]
Coleman	South	(Facility decommissioned; no instream flow requirement)											

A = Accretion flows downstream of the Keswick Dam can exceed 100% of maximum WUA for steelhead spawning in the portion of the Keswick reach available to anadromous fish and can exceed the predictive capability of the IFIM model. Accretion flows downstream of the Keswick Dam provide >90% of maximum WUA for steelhead rearing in the portion of the Keswick reach available to anadromous fish.

F = On occasion the release is not attainable due to the quantity of inflow reaching North Battle Creek Feeder Diversion. Additional inflows to the North Battle Creek Feeder reach are occasionally received from the junction box of the Volta 2 Powerhouse tailrace and Cross-County Canal a short distance downstream.

S = Eagle Canyon Dam releases reported in this table include releases from Eagle Canyon Springs (those springs located downstream of Eagle Canyon Dam that were included in the “interim flow agreement” between PG&E and USBR; USBR 1998a).

P1 = The prescribed instream flow will be the total available inflow in the South Fork upstream of the South Powerhouse at times when the available inflow is less than the prescribed flow.

Table 4. Summary of prescribed instream flow releases from diversions in tributaries affecting the anadromous reaches of Battle Creek and tributaries based on best available information by the Battle Creek Working Group Biological Team.

Diversion	Monthly Minimum Flow (cfs) To Be Released From Tributary Diversions											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Eagle Canyon Spring	All[D]	All[D]	All[D]	All[D]	All[D]	All[D]	All[D]	All[D]	All[D]	All[D]	All[D]	All[D]
Soap Creek	(Facility decommissioned; no instream flow requirement)											
Lower Ripley Creek	(Facility decommissioned; no instream flow requirement)											
Baldwin Creek	5[C]	5[C]	5[C]	5[C]	5[C]	5[C]	5[C]	5[C]	5[C]	5[C]	5[C]	5[C]

D = Flow from Eagle Canyon Springs enters Battle Creek in the vicinity of Eagle Canyon Dam and is included in Eagle Canyon Dam releases shown on Table 1. These Springs were included in the "interim flow agreement" between PG&E and USBR will be released to maximize cooling of Battle Creek.

C = The flow value reported for Baldwin Creek represents the maximum instream flow release.

Table 5. Biological principles that the USFWS, NMFS, CDFG, and USBR consider essential for salmonid restoration in Battle Creek (modified slightly from Table 9 in Ward and Kier 1999).

Biological Effectiveness – Restoration actions must 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.

Restoring Natural Processes – Restoration actions must incorporate measures that mimic the hydrologic conditions under which Battle Creek anadromous fish resources evolved.

Biological Certainty – Restoration actions must 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.

Hatcheries and Wild Salmon

During the 1990s, fisheries biologists have begun to recognize that the operation of salmon hatcheries can negatively impact naturally reproducing populations of fish (see Steward and Bjornn 1990 for a review). These impacts can manifest themselves in several broad ways including: direct competition for food or other resources between wild and hatchery fish (see Berejikian et al. 1996 for a review), predation of hatchery fish on wild fish (Hilborn 1992), decreased genetic fitness through adaptation to hatchery environments or mixing between hatchery and wild stocks (e.g. Berejikian 1995, Berejikian et. al. 1996), and increased fishing pressure on wild stocks due to artificial production (Hilborn 1992) or, in the case of Battle Creek chinook salmon, unharvested surpluses of hatchery fish under fishing regulations that have been restricted to protect wild or sensitive runs.

The actual extent of the CNFH's impacts are largely unknown (USFWS 1993, 1996, 1998a), and although these documents assert that impacts on winter-run chinook from predation, competition, migratory displacement, and disease transmission associated with CNFH operations are minimal or non-existent, these conclusions were not based on completed investigations. Studies specifically designed to evaluate these potential impacts of CNFH operations have not been completed to date for winter-run, nor for the three other chinook stocks, nor for steelhead. Furthermore, the conclusions in these three documents that suggested minimal impact of CNFH operations on naturally-produced fish were derived during a period when Battle Creek populations of chinook salmon and steelhead were depressed (USFWS 1998a). As restoration of these populations proceeds, increased interactions between CNFH production and natural fish populations can be expected, suggesting that more investigation of possible impacts is required.

Ecosystem Function

Plans for the restoration of the Battle Creek watershed have been founded on ecosystem-based restoration principles (see the section "Anadromous Salmonids and Ecosystem Function" in Ward and Kier 1999) as are the priorities of the USFWS (USFWS 1994). Restoration under the ecosystem-based approach refers to efforts primarily aimed at identifying and addressing, in the aggregate, suites of key attributes of the affected ecosystem (Bay Institute 1998). This differs fundamentally from species-level efforts, which are based instead upon attempts to identify and address the "limiting factors" of particular species (Bay Institute 1998). A major aspect of the implementation of ecosystem-based restoration is to avoid reliance on mechanical systems that are prone to improper design and unpredictable breakdowns (Cairns 1990). In fact, the most recent developments in the restoration of salmon and steelhead habitat in the Battle Creek watershed upstream of CNFH (Table 2) have established such ecosystem-based approaches to restoration as the standard within the Battle Creek watershed.

Fish hatcheries, including CNFH, are highly mechanized systems designed to replace the spawning, incubation, and rearing functions of naturally occurring habitat. These mechanized systems or processes are prone to failure. Black (1999) cites several instances where CNFH production was jeopardized due to failures of mechanical systems. Most recently, political pressure (e.g. NORCAL 1999; NMFS 1999) lead to deviations from goals[4] for decreasing potential competition and avoiding displacement of wild fish by not releasing salmon fry from CNFH (USFWS 1998a). This pressure prompted the unplanned release of about two million chinook salmon fry from CNFH, an action which deviated from assurances in USFWS (1998a) and which may have negatively affected natural fish populations. Failures, such as these, in either mechanical systems or in related decision-making processes, are inevitable despite the best of intentions, and should be planned for – especially if potential failures jeopardize or threaten the restoration of natural Battle Creek salmonid populations.

As mechanized systems prone to failure, fish hatcheries violate the ecosystem-based approach to restoration. Though CNFH, as a mitigation facility for lost habitat, was not intended to be ecosystem-based, current restoration efforts in Battle Creek, as well as current USFWS policy (USFWS 1994), have been based on an ecosystem approach. The ecosystem approach suggests restoration should not be dependent on mechanical systems or processes, to offset impacts of CNFH operations, or else the sustainability of restoration efforts in Battle Creek may be compromised.

Isolation Versus Synthesis of Hatchery Operations

Two schools-of-thought have arisen on the subject of the compatibility of hatcheries with the protection or restoration of wild fish stocks. One approach is to isolate hatchery operations to the maximum extent in order to minimize the potential impacts of hatchery operation on naturally spawning populations. The other approach is to synthesize hatchery and wild populations as much as possible so that there is little- or no distinction between hatchery and wild populations, and hence, no negative impacts.

Bugert (1998) provides one example of the approach of isolating hatchery operations from wild stocks. He suggests that effective broodstock collection should include criteria such as 1) an ability to collect only the targeted population for supplementation, 2) a capability to capture all age classes of the target population without injury or stress, 3) an equal collection efficiency during both the peak and nadir of the hydrograph, 4) an ability to sort hatchery and naturally produced salmonids, 5) unimpeded passage of non-targeted species and populations and, at times, most of those fish in the targeted population, 6) compatibility with State and federal rules governing dams. Though Bugert (1998) focuses primarily on broodstock collection at supplementation hatcheries, this isolation approach could be extended to other aspects of hatchery operations including juvenile release, management of hatchery effluent, and disease management, and is equally valid where restoration, rather than supplementation or compensation, is the primary objective.

The operation of the Warm Spring National Fish Hatchery (WSNFH), in the Deschutes River watershed of Oregon, exemplifies the alternative “synthesis” approach (Olson et al 1995; and a presentation to the Battle Creek Working Group by Douglas Olson and Mike Paiya,

[4] Goals of a “zero target fry program” were arrived at through consultation between NMFS and USFWS. Releases of fry in previous years was an incidental by-product of taking more salmon eggs at CNFH than were needed for established goals, rather than as part of a stated policy or program (Jim Smith, USFWS, Red Bluff, California, pers. comm.).

USFWS, on December 18, 1998). All returning adult salmon at WSNFH, in addition to all non-target species such as suckers, whitefish and bull trout, are sorted and managed based on evolving criteria in an effort to insure that target stocks of salmon that are kept for broodstock are genetically similar to naturally spawning populations and that no hatchery-reared spawners are allowed to spawn in the wild upstream of WSNFH. The technique of partial volitional release of juveniles is used in an attempt to minimize potential negative impacts from juvenile production on wild stocks.

Several aspects of the purpose and circumstances at CNFH/Battle Creek suggest that, under a fisheries restoration scenario, CNFH should be operated according to the "isolation" approach as opposed to the "synthesis" approach. First, CNFH was not designed to replace or supplement fish populations in Battle Creek; it is a mitigation facility to replace stocks of salmon in the Sacramento River and is located on Battle Creek only as a result of historical/technological circumstances (Black 1999).

Second, the production objective of CNFH is to "increase the chinook salmon contribution to commercial and sport fisheries, and steelhead trout contribution to sport fisheries" (USFWS 1987; 1996) which is much different than the stated objectives at WSNFH which are 1) optimizing natural production in Warm Spring River, the stream on which the hatchery is located, 2) optimizing harvest, and 3) maintaining the biological and genetic characteristics of the local fish populations in both the hatchery and stream environments (Olson et al. 1995).

Third, CNFH operates under different circumstances than WSNFH. Most notably, production at CNFH, based on established production objectives, is much greater than production at WSMFH. The average return of fall-run chinook to Battle Creek from 1987 to 1997 was 45,000 fish (Data from CDFG's "Grand Tab" data set, CDFG, Red Bluff, California.) compared to a 14 year mean of 832 spawning spring-run chinook salmon in the Warm Springs River (Olson et al. 1995).

Fourth, Battle Creek supports four separate races of chinook salmon whose spawning periods overlap temporally whereas the Warm Springs River is much simpler with only one race of chinook salmon. Genetic analyses of chinook captured at CNFH indicate that hatchery operations may already be causing hybridization between races of chinook salmon; this risk is not present at WSNFH.

Fifth, it may be infeasible for CNFH to develop tools similar to WSNFH which allow for marking, identification, sorting, and management of individual fish, especially in peak years when the number of fish returning to Battle Creek can exceed 100,000 fall-run chinook salmon. For example, the costs and time constraints associated with marking and tagging 100 percent of the huge number of fall-run chinook produced at CNFH make this task difficult and neither automated nor manual sorting of up to 100,000 adult fall-run chinook during a three month spawning period are considered feasible at this time (Scott Hamelberg, USFWS, during discussions about the future of the CNFH Barrier Dam, Battle Creek Working Group – CNFH Barrier Dam Meeting, December 18, 1998).

Sixth, stakeholders and agencies interested in the restoration of Battle Creek fisheries have been working collaboratively to modify facilities at CNFH (see Ward and Kier 1999 for details) and a number of these facility modifications will act to isolate CNFH operations from Battle Creek. For example, an ozone treatment plant is currently being installed to keep fish pathogens out of the hatchery water supply which will effectively maintain two separate fall-run chinook populations, an IHN-infected natural population and a INH-free hatchery population. Water supply intakes to the CNFH are being improved with fish screens and plans for an interim tailrace barrier at the Coleman Powerhouse are being developed (USBR 1998). Proposals have been made to modify the CNFH barrier dam, in part to keep hatchery-produced fall-run fish out of the main portion of the Battle Creek watershed, and also to modify the fish ladder at the barrier dam so that it will not impede salmon migrating into the watershed at high flows (USFWS 1999b).

Finally, and most importantly, dependence on CNFH as part of a Battle Creek restoration program would violate the adopted ecosystem-based restoration principles. For instance, the CNFH barrier dam, which is used to shunt adult salmonids into the hatchery for broodstock collection, has historically been used to limit access of salmonids to the Battle Creek watershed and still poses a challenge to the restoration of Battle Creek salmonids. The existing fish ladder on the barrier dam is not consistent with criteria applied to other dams in the watershed at times of higher flows (CDWR 1997), which usually occur from December through June when steelhead and winter-, spring- and late-fall-run chinook migrate into the watershed. This dam, constructed only seven years ago, is already showing signs of deterioration. Even if these conditions are fixed, at an estimated cost ranging from $1.4 million to $2.2 million, future deterioration or unanticipated problems with the fish ladder could continue to impede adult salmonids from reaching the vast majority of the restored habitat in the Battle Creek watershed.

Other examples of hatchery operations or facilities that need to be founded on ecosystem-based principles of conservation genetics and ecology that were established in the restoration planning for middle and upper reaches of Battle Creek include: fish screens at the hatchery water supply intakes, releases of juvenile salmon, management of adults returning to CNFH, and possible genetic problems associated with broodstock selection. Alternatives to current hatchery operations may exist which are more closely founded on ecosystem-based restoration principles.

By managing CNFH to isolate hatchery operations from wild fish in Battle Creek, interference in the recolonization of restored habitat by populations of chinook and steelhead will be minimized. The full range of complex ecological and life history interactions exhibited by the unique mix of four races of chinook salmon will be expressed if interference with natural ecosystem processes from hatchery operations and other unforeseen impacts are minimized.

In conclusion, the operation of CNFH should follow the approach of maximizing its isolation from the fish populations and habitat of the Battle Creek watershed, without impairing the hatchery's ability to achieve its mitigation obligations, because CNFH is unlikely to ever achieve the sophisticated level of synthesis with natural populations attempted at WSNFH, without dramatically scaling back production and shifting objectives away from its mitigation requirements, and is unable to operate according to ecosystem-based restoration principles.

Cost-effective means of de-coupling CNFH from the Battle Creek watershed need to be explored.

Isolating CNFH operations from Battle Creek, without impairing the hatchery's ability to achieve its mitigation obligations, is consistent with policies of the USFWS and CDFG. For example, the CVPIA seeks to minimize fish losses incurred as a result of operations or maintenance of the hatchery as an element of the Central Valley Project and specifies that habitat replacement, rather than hatchery production, is the preferred means of mitigating for unavailable losses (CDFG 1997b). The paradigm of isolating hatchery activities is also consistent with the USFWS's (1994) Action Plan for Fishery Resources and Aquatic Ecosystems and the Report of the National Fish Hatchery Review Panel (1994) undertaken at the request of the USFWS. Furthermore, several policies of CDFG, which have been suggested for necessary inclusion within any planning process for CNFH, would all be satisfied by the approach of isolating CNFH from Battle Creek (CDFG 1998). This conclusion, therefore, is one of the paradigms that was used to frame possible alternatives and issues outlined in subsequent sections of this report.

Habitat in Battle Creek Downstream of CNFH

Battle Creek flows for approximately five miles downstream of CNFH before entering the Sacramento River. About three miles of this reach is considered to be spawning habitat for chinook salmon (Coots and Healey 1966). In addition to providing a significant proportion of the total amount of spawning habitat for fall- and late-fall-run chinook in the Battle Creek watershed, lower Battle Creek is important to the restoration of fish populations throughout the Battle Creek watershed because this habitat serves as a migration corridor for fish swimming-to or migrating-from the watershed upstream of CNFH. Two main threats to salmonids in this important habitat have been identified including water diversions and streambed alteration, while the majority of actions to improve the habitat have focused on the protection of bald eagle nesting habitat and the public acquisition of riparian lands adjacent to lower Battle Creek.

The lower most sections of Battle Creek are within the Sacramento River's meander belt. This habitat supports critical activities for a wide variety of species, including critical spawning and rearing areas of all races of chinook salmon, steelhead, pacific lamprey, and many sensitive wildlife species. The lower one mile of Battle Creek is also utilized by some of the juvenile salmon of all races that were spawned in the Sacramento River. The primary ecological stressors in this area are related to the close proximity of this reach to rapidly expanding urban areas 10 to 15 miles upstream. This proximity to urban areas is increasing the pressure for land development, bank protection, and gravel mining. These activities now occur to a minor extent in this stream reach with current proposals for more of each activity.

Water Diversions

Water is diverted from Battle Creek downstream of CNFH into two irrigation ditches known as the Gover and Orwick ditches. As early as 1969, water diversions into the Gover Ditch have been cited as a factor impacting salmonids in Battle Creek. Fish screens in place at the headworks to the Gover Ditch in 1969 were "probably adequate" for screening out wild fish but were not “satisfactory” for screening out large number of juvenile salmon released from CNFH, many of which were often small and weak upon release (CDFG 1969a). The initial response to this situation was to release CNFH juveniles downstream of the Gover Ditch headworks. However, this solution was considered untenable and longer-range solutions were suggested including: 1) improving physical conditions within CNFH to allow for more efficient handling of fish for release downstream of the Gover Ditch; 2) installing a permanent bypass pipe from the screen area to Battle Creek below the point of diversion; or 3) routing hatchery effluent directly to the Gover Ditch, decommissioning the Gover Ditch headworks, and releasing juveniles directly from the hatchery into Battle Creek (CDFG 1969b). Finally, a permanent bypass pipe from the screen area to Battle Creek below the point of diversion, and barrier racks to prevent adult movement into the ditch, were installed.

Though the fish screen at the Gover Ditch was eventually improved to effectively preclude juvenile fish from being diverted from Battle Creek, recent assessments of these facilities have concluded that improved fish screens or barrier racks need to be installed at the Gover Ditch headworks and wastegates to prevent adult salmon from entering the Gover Ditch (USFWS 1995, 1997). Recent assessments have also prioritized the need for fish screens at the Orwick Ditch (CDFG 1994; USFWS 1995, 1997).

Streambed Alteration

Flooding in lower Battle Creek and adjacent riparian areas in 1964, and subsequent erosion of adjacent agricultural lands, prompted the U.S. Army Corps of Engineers to undertake a series of actions to alter the bed and banks of the stream in 1965 and subsequent years (CDFG 1965a). Aspects of this work, including alteration of about 500,000 sq. ft. of streambed, gravel removal, one-quarter mile of stream channel alignment, dewatering portions of the channel, levee construction, and operation of heavy equipment in the stream channel, directly impacted salmon habitat and resulted in direct mortality of salmon juveniles (CDFG 1965b, CDFG 1965c).

Interest in gravel removal, mining, and streambed alterations in lower Battle Creek continued, its validity was questioned, and steps to prevent negative impacts on fish were explored in the late 1960s (e.g. CDFG 1967a, 1967b, 1967c), the 1970s (USFWS 1971; USACE 1971), and the 1980s (Kitayama 1980; CDFG 1980). More recently, several assessments of the restoration potential of Battle Creek have suggested that streambed and bank alterations in Battle Creek should be stopped and the stream habitat should be restored to more natural conditions (CDFG 1993a; Bernard et al. 1996).

Bald Eagle Nest

Bald eagles, protected under the Endangered Species Act, nest at a site near the Gover Ditch headworks. Native fish that comprise part of the forage base for these eagles need to be able to pass the CNFH barrier dam (CDFG 1997a). Concerns have been expressed that construction at the site of the Gover Ditch headworks should not disturb any nesting eagles (Harry Rectenwald, CDFG, Redding, California, pers. comm.).

Public Acquisition of Riparian Areas in Lower Battle Creek

Key ecosystem functions of riparian habitat, shaded riverine aquatic habitats, and instream habitats could be restored by preservation and expansion of riparian areas in lower Battle Creek. For example, protecting and reestablishing extensive shoreline vegetation would provide woody debris; leaf and insect drop; and provide better habitat for wildlife species such as bank swallow, bald eagle, great blue heron, elderberry longhorn beetle, and possibly yellow billed cuckoo.

An effort by public agencies to protect fisheries resources in lower Battle Creek by acquiring riparian property was initiated as a result of the Anadromous Fish Act in the 1960s (CDFG 1967a, 1967b, 1967c). In 1982, the State of California designated 418 acres of riparian lands in lower Battle Creek as the Battle Creek Wildlife Area to be managed by CDFG to help preserve and protect wetlands, riparian habitat, and the anadromous fishery (USFWS n.d.). The USFWS is cooperating in this effort and has provided a "conceptual guide for new improved visitor watchable wildlife experiences" to integrate interpretive programs at CNFH and the Battle Creek Wildlife Area (USFWS n.d.).

Presently, efforts are under way by the Trust for Public Lands, CDFG, and the Bureau of Land Management to acquire fee title and conservation easements on the Gover Ranch to protect existing riparian corridors and provide an opportunity to reestablish natural hydrologic function along Battle Creek and the nearby Sacramento River. A proposed combination of conservation easements and fee title acquisition would protect existing riparian corridors along roughly 3.5 miles of the Sacramento River and 4.5 miles of lower Battle Creek.

TECHNICAL PLAN

CNFH Operations: Seeking Compatibility With Restoration

The novel nature of fish restoration in Battle Creek, and the need for multiple stakeholders to contribute to management decisions, suggests that this document is not suited for any specific recommendations with regard to future management actions intended to isolate the impacts of CNFH operations from fish populations being restored in Battle Creek. Instead, this portion of the Technical Plan presents a decision matrix which is intended to help fisheries managers and stakeholders explore alternative ways for managing CNFH impacts and lower Battle Creek. This section lists and explains issues that need to be considered by any alternative management plan and lists several possible alternatives. These issues and alternatives were selected within the paradigms outlined in the previous section. It is anticipated that the decision matrix developed in this plan, and decisions regarding possible alternative management scenarios, will be further refined in a collaborative process among resource agencies and stakeholders through the BCWG. The prioritization of issues and the list of possible alternatives will likely be modified, as well, during this collaborative process.

Issue: Water Management

CNFH has the right to divert up to 122 cfs of water (USFWS 1996) for hatchery operations from two locations in Battle Creek approximately 1 mile upstream of the hatchery and from one location in Battle Creek Hydroelectric Project's Coleman Canal about 0.75 miles upstream of the hatchery. Approximately 75 cfs has been diverted in practice during recent years. Until recently, these three water intakes were not screened to prevent fish entrainment but current efforts are underway to install fish screens on these intakes (see Ward and Kier 1999 for a review of this work). However, fish screens have been demonstrated to be problematic and prone to failure. Restoration standards in Battle Creek have favored removal of water diversions over installation of fish screens. In those cases where fish screened diversions remain in place, as is anticipated for diversions supplying water to CNFH, strict and rigid guidelines for operation, maintenance, and replacement of fish screens are specified, and provisions are made so that diversions are not operated during periods of screen failure (Table 2). Should a policy of "fail-safe" screens be implemented at CNFH, stopping water diversions in the case of screen failures could jeopardize fish production in the hatchery unless the redundancy associated with having three separate water intakes was used to maintain a steady water supply and avoid impacts to hatchery and wild fish.

Water used in CNFH is returned to Battle Creek at the hatchery site after it passes through abatement ponds rebuilt in the mid-1990s or is directly discharged into Battle Creek via fish ladders at the hatchery or through a waste water channel. Effluent from CNFH has violated federal Clean Water Act standards in the past but the new abatement ponds have rectified this situation and effluent has met federal standards since reconstruction (Tom Nelson, CNFH manager, USFWS, Anderson, California, pers. comm.). However, the effect of hatchery operations on the temperature of hatchery effluent has not been investigated. Water moving through the hatchery would be expected to warm, especially during summer when elevated water temperatures are most commonly a problem. However, whether such potential warming affects fish habitat in lower Battle Creek is currently unknown. Likewise, the reduction in instream flows of between 75 and 122 cfs in the approximately 1 mile long hatchery bypass reach has not been studied to determine if fish habitat is significantly reduced by hatchery water withdrawals.

Issue: Management of Salmon Returning to CNFH

Access to Restoration Habitat in the Middle Reaches of Battle Creek

All fish that migrate from the Sacramento River to the middle reaches of Battle Creek, where the bulk of proposed habitat restoration will take place, must pass over a barrier dam operated by CNFH. However, the fish ladder that allows passage over the barrier dam is often closed to meet various fisheries and hatchery management objectives. In general, closure of this fish ladder denies access to the restoration habitat in the middle reaches of Battle Creek[5]. For this reason, management of the CNFH barrier dam has been singled out as one of the primary factors controlling the abundance of salmon and steelhead in Battle Creek and an area of primary concern for the restoration of anadromous salmonids in the watershed (USRFRHAC 1989; CDFG 1993c, 1996c; USFWS 1995a, 1997c; Bernard et al. 1996).

Reasons for closing the barrier dam have included: collecting broodstock for the CNFH (USFWS 1998b); preventing fall-run and late-fall-run chinook salmon, that are highly infected with IHN virus, from transmitting disease to CNFH by entering areas of the watershed that serve as water sources for CNFH (USFWS 1990); temporally and spatially separating spring-run and fall-run fish to maintain/manipulate stock identity (USBR 1998a); preventing fish from reaching habitat degraded by lack of flow and large, unscreened diversions; preventing the swamping of habitat by huge numbers of hatchery reared fish; and monitoring fish movement into the Battle Creek watershed (USFWS 1996a). However, restoration actions recently undertaken in the watershed, and those proposed to take place in the near future, alleviate much of the former concern which prompted prolonged closures. For instance, the construction of ozone treatment facilities to disinfect water at CNFH alleviated disease concerns for the upstream passage of salmon (USFWS 1998b), and anticipated flow and habitat restoration actions, including screening diversions, will alleviate concerns for degraded quality and quantity of habitat.

Until recently, the fish ladder at the CNFH barrier dam was open to fish passage from March through June and was closed during the remainder of the year (Table 6). In 1997, a fish trap was installed at the upstream end of the fish ladder for the purpose of passing non-winter-run fish and non-hatchery winter-run upstream of the barrier dam. This allows the fish ladder to be operated as early as mid-February, depending on flow conditions. The period when the fish ladder is closed and access to the restoration habitat in the middle reaches of Battle Creek is denied, overlaps to varying degrees with the periods of migration and spawning of all four races of chinook salmon, and steelhead, in Battle Creek. Fall- and late-fall-run chinook that reach the barrier dam when the ladder is closed are either shunted into CNFH via a second fish ladder, or are confined to the habitat in lower Battle Creek. The latest-arriving late-fall-run chinook are able to access habitat upstream of CNFH when the fish ladder is open in March and April (Table 6). Winter-run chinook that arrived early or late in their migration and spawning periods would also be confined downstream of the barrier dam (Table 6). However, the fish ladder at the

[5] The barrier dam may be passable, even with the fish ladder closed, when high runoff events (exceeding 350 cfs) allow fish to leap or swim over the dam (USFWS 1995b).

barrier dam is open during the peak of winter-run migration and spawning (Table 6). The peak of spring-run migration occurs when the fish ladder is open but spawning, and a protracted period of migration from July to mid-October, occurs when the ladder is closed. Spring-run that are blocked by the closure of the fish ladder may hold in the mainstem Sacramento River before ascending Battle Creek just ahead of the fall-run (USFWS 1957). The fish ladder is closed for seven of the eight months that steelhead migrate into Battle Creek (Table 6).

Carrying Capacity of Fall-run Chinook Spawners in Lower Battle Creek

Adult salmon returning to Battle Creek or CNFH are blocked by the barrier dam at CNFH. Fish in excess of hatchery brood stock needs have been released upstream of the dam (primarily steelhead) or have been held within the 5.09 miles of Battle Creek habitat downstream of the barrier dam (primarily fall- and late-fall run chinook salmon), of which about three miles is considered to be spawning habitat for chinook salmon (Coots and Healey 1966). Enormously successful runs of fall-run chinook have been produced by CNFH in recent years; average returns in the four most recent years of record[6] approached 45,000 fish (Figure 2). Since 1987, an average of nearly 27,000 fall-run chinook were held in the 3 miles of spawning habitat in lower Battle Creek, prompting concern that the carrying-capacity for fall-run chinook in lower Battle Creek is being exceeded.

Although no formal estimates of the number of spawning fall-run chinook that can be accommodated in lower Battle Creek has been conducted, rough estimates can be made using existing sources of information:

1) A limiting-life stage model developed by the BCWG (Ward and Kier 1999), using instream flow modeling data from TRPA (1998), estimates that habitat in the mainstem of Battle Creek could support approximately 4.6 redds per 1,000 feet of stream at flows of 345 cfs[7]. This density of redds in the three miles of lower Battle Creek, assuming that, on average, one redd is used by three fish, yields an estimated carrying-capacity of about 219 fish.
2) If flow modeling data is dropped out of this estimate and the limiting life stage model assumption that 194 square feet is necessary for each redd, including a defense area (Mark Gard, USFWS, Sacramento, California, pers. comm.), is applied to a 1989 estimate of 58,000 square feet of spawning habitat in the 15.15 miles of the mainstem Battle Creek (CDFG 1995c), and recognizing that the habitat below CNFH represents about one-third of the mainstem Battle Creek, then about 299 adult fall-run chinook could be supported by this habitat.

[6] Preliminary estimates for 1998 suggest that total fall-run returns to the Battle Creek watershed were of similar magnitude as total returns in 1995 through 1997.

[7] The average monthly discharge of Battle Creek during the fall chinook spawning period is 425 cfs but the TRPA (1998) model was not designed to predict habitat at discharges greater than 345 cfs. Habitat area and discharge were inversely related at flows between 90 and 345 cfs. If this relationship holds true for flows up to 425 cfs, the actual number of redds that could be supported in lower Battle Creek would be even lower.

[8] Coots and Healey (1966) estimated that 12,000 fall-run chinook used lower Battle Creek downstream of CNFH and that 430,000 square feet of spawning gravel was present compared with about 19,333 square feet in 1989. However, their estimate of fish "usage" was not a carrying-capacity estimate and likely included CNFH-produced fall-run that were restricted from moving upstream or into CNFH.

Table 6. Seasonal occurrence of selected life stages of anadromous salmonids in the Upper Sacramento River, California, compared with the times that fish ladders are open to fish passage under existing conditions.

Life Stage	Species	Month											
		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Adult Migration	Winter Chinook				X								
	Spring Chinook					X							
	Fall Chinook										X		
	Late-Fall Chinook	X											
	Steelhead												
Spawning	Winter Chinook						X						
	Spring Chinook									X			
	Fall Chinook											X	
	Late-Fall Chinook		X										
	Steelhead												
Barrier Dam Ladder Open													
Hatchery Ladder Open													

X = Denotes approximate peak of life stage if a significant peak occurs.

3) USFWS (1995) estimated that as many as 4,500 fall-run could be expected to spawn in the approximately 26 miles of Battle Creek suitable for fall-run under fully restored conditions (Ward and Kier 1999). If fall-run were evenly distributed throughout only the best[9] 17.69 miles of this habitat, then approximately 1,271 fish would use lower Battle Creek.

Though these three estimates are crude, they suggest that lower Battle Creek cannot support spawning populations much larger than the range from 219 to 1,271 fall-run chinook salmon. Even if these estimates were off by a factor of 10, resulting in a carrying capacity estimate ranging from 2,190 to 12,710 fish, the number of adult fall-run chinook that have returned to lower Battle Creek in recent years have exceeded the amount of habitat available. In fact, recent average returns of fall-run chinook to CNFH and the 3 miles of spawning habitat in lower Battle Creek have exceeded the total estimated carry-capacity of the 26 miles of fall-run habitat in Battle Creek (4,500 fall-run chinook; USFWS 1995) by a factor of 10.

Decoying Sacramento River Fall-run Chinook to Battle Creek

Enormous returns to CNFH and lower Battle Creek[10] may have the potential to falsely attract into Battle Creek naturally spawning populations of fall-run chinook natal to the Sacramento River. Under current operations, when Battle Creek receives greater than 25,000 to 35,000 fall-run spawners, the excess spawners do not contribute to production because both the stream habitat downstream of the CNFH barrier dam, and the hatchery itself, are saturated with spawn. Excess unspawned salmon have been disposed of in recent years by running the hatchery fish ladder to attract them into the disposal system at CNFH.

False attraction of fish native to the Sacramento River would reduce the number of wild fish in the Sacramento River population that the hatchery intends to supplement and would contribute to genetic mixing that may not otherwise occur. Restoration measures on the mainstem Sacramento River, that may total over $326 million[11] of investment upon completion, would have reduced effectiveness if false attraction were occurring.

Naturally spawning fall-run chinook salmon populations in the Sacramento River are currently very low compared to the long-term average from 1952 to 1997 and cohort replacement rates of less than 1.0 in the late 1980s and early 1990s have caused concern among some researchers (DEFT 1998). Return data in 1995 and 1996 (and possibly 1998, based on preliminary estimates; Harry Rectenwald, CDFG, Redding, California, pers. comm.) shows that relatively few fall-run chinook returned to spawning areas in the upper Sacramento River in the 2 (or 3) years when relatively large numbers of fall-run have returned to CNFH and lower Battle Creek (Figure 3). Fall-run chinook from CNFH, lower Battle Creek, and the upper Sacramento River should be exposed to similar causes and levels of mortality in the river, estuary, and ocean. Indeed, fluctuations in these three populations were in general agreement in the 1990s but the

[9] See Table 14 of Ward and Kier (1999) for the ranking of habitat quality by reaches – the best fall-run chinook habitat exists in the Coleman, Mainstem, and Battle Creek Mouth reaches, though other fall-run chinook habitat exists in other reaches.
[10] The vast majority of fall-run chinook salmon returning to lower Battle Creek are believed to be fish produced at CNFH.
[11] See the subsequent section on economics for a refinement of this number.

Sacramento River population seems to have had different return rates than the other two populations in years when very large numbers of adults return to CNFH and lower Battle Creek (Figure 3). These observations could be caused by differential survival rates among the three populations, or could be manifested by these data if fish returning to the upper Sacramento River were, instead, attracted-to and counted-in, Battle Creek.

Similar instances of large spawning populations prompting adults from other populations to be falsely attracted toward the larger population have been previously documented. For example, Nicholas and Van Dyke (1982, as cited in Quinn 1997) estimated that 64.7 percent of wild coho salmon (*O. kisutch*) returning to the Yaquina River, Oregon, entered the Oregon Aquafoods Hatchery. Quinn (1997) concluded that "such decoying of wild salmon into hatcheries both reduces the number of wild fish in the stream and contributes to genetic mixing." Furthermore, straying rates may increase when spawning population densities are low (Dr. Tom Quinn, University of Washington, Seattle, Washington, pers. comm.), which may be the case for fall-run in the Sacramento River in light of recently low returns. However, these observations of possible decoying of Sacramento River fall-run to Battle Creek are preliminary and are not statistically conclusive at this time. Future spawner population sizes should be analyzed to determine if wild Sacramento River fall-run are being decoyed to Battle Creek. Also, it may be possible that low cost preventative measures might be taken in Battle Creek to stem any potential problem.

Possible Hybridization at CNFH

Concerns regarding suspected genetic hybridization between spring and fall-run chinook in Battle Creek have been expressed in the past (CDFG 1993b, 1998b; see Ward and Kier 1999 for a review of this topic) and such concerns have been included as justification for managing fish passage at the CNFH barrier dam (USBR 1998a). New information regarding these genetic concerns has been recently made available which should focus this concern (Banks et al., submitted).

In an unpublished research paper submitted to a prominent fisheries science journal in late February 1999, Banks et al. (submitted) reported that significant Hardy-Weinberg-Castle (H-W-C) linkage disequilibria was observed in two genetic samples of fall-run chinook salmon collected from Coleman National Fish Hatchery in 1993 (representing genetic material from 134 individual fish) and 1995 (representing genetic material from 71 individual fish). In contrast, 35 out of 41 other chinook salmon populations sampled from the Central Valley were in H-W-C equilibrium.

H-W-C linkage equilibrium indicates that the frequency of a given gene remains constant from generation to generation (Klug and Cummings 1993) and disequilibrium is generally a sign of admixture within runs. Three principle causes could give rise to the apparent disequilibrium reported by Banks et al. (submitted) including hybridization, sampling individuals from different runs, and sampling individuals from the same family. However, family structure is not likely the cause of observed disequilibrium at CNFH in this case because it is not likely that the 205 individuals sampled at CNFH were from only a few families and because the disequilibrium observed at CNFH is stronger than that which is usually observed based on family structure (Dr. Michael Banks and Dr. Dennis Hedgecock, University of California at Davis, Bodega Marine

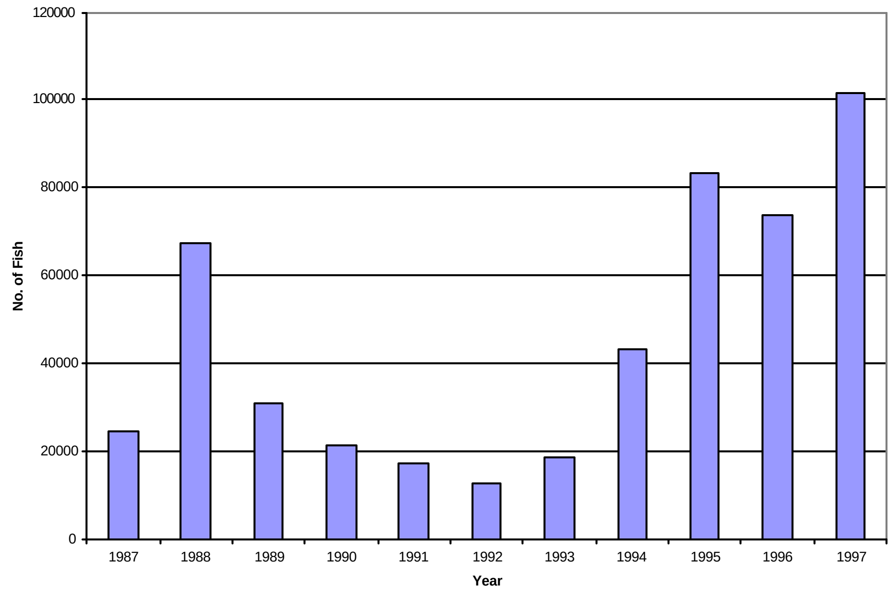

Figure 2. Total numbers of fall-run chinook salmon returning to the Battle Creek watershed in the years that Red Bluff Diversion Dam has been operated to optimize salmon passage. Data from CDFG's "Grand Tab" data set, CDFG, Red Bluff, California.

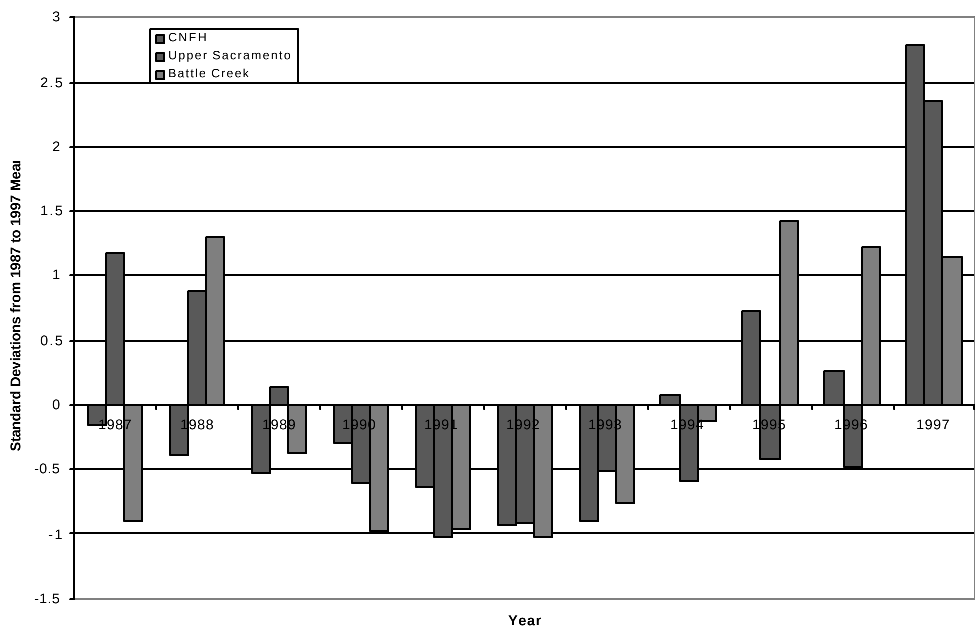

Figure 3. Trends in three populations of fall-run chinook salmon from 1987 to 1997.

Lab, Bodega, California, pers. comm.). Similarly, in the case of the CNFH samples, there is no real distinction between hybridization and sampling individuals from different runs, as possible causes for disequilibrium, because the samples from CNFH were taken from fish used as broodstock. If the sampled individuals were indeed from different runs, then hybridization would be the direct result of the hatchery spawnings.

These observations strongly suggest that hybridization at CNFH, probably between spring-run and fall-run chinook salmon, is the cause for the observed disequilibrium. Furthermore, this suspected hybridization would not be an artifact of historical hatchery practices (spring-run were propagated at CNFH in the 1940s; Ward and Kier 1999) and must be caused by recent cross-fertilization because older effects would have been obscured over time (Dr. Michael Banks and Dr. Dennis Hedgecock, University of California at Davis, Bodega Marine Lab, Bodega, California, pers. comm.). Finally, hybridization would have likely taken place at CNFH and not in the wild. Consistent genetic differences among Central Valley runs (Banks et al. submitted), as well as consistent observations of H-W-C equilibrium in dozens of other samples of Pacific salmon from throughout their range, indicate that seasonal races of chinook salmon rarely, if ever, hybridize in the wild.

Hybridization at CNFH between spring- and fall-run chinook is a likely occurrence given that temporal overlap of both runs in Battle Creek, as well as variance in salmon life history patterns, makes simultaneous capture of adults from both runs highly likely and given that morphological features do not allow reliable discrimination between the runs. This problem was first identified in the early operation of CNFH (Cope and Slater 1957) and remains challenging given limited power for individual identification through genetic fingerprinting (Smouse and Chevillon 1998). Banks et al. (submitted) concluded that “spawning in the hatchery context is one area where we must remain particularly alert for evidence of between-run hybridization, for here spawning choices are not made by the fish.”

Current operations of the CNFH barrier dam, and operational scheduling for several of the alternatives for managing the barrier dam introduced in subsequent sections of this report, rely on the choice of arbitrary dates to classify distinguish between “spring-run,” “fall-run,” and “late-fall-run.” Currently, chinook salmon arriving from about October 10 to late November are captured and used as “fall-run” broodstock (Tom Nelson, USFWS-CNFH, Anderson, California, pers. comm.). “Late-fall-run” broodstock collection takes place after January 1. The genetic observations of Banks et al. (submitted) suggests that using these date distinctions introduces an artificial evolutionary selection factor that is likely to lead to biologically significant hybridization which may threaten the restoration of spring- and fall-run chinook in Battle Creek.

Geneticists have suggested that the prevention of any future human-induced hybridization of chinook salmon runs should be a guiding principle to restoration of Battle Creek salmonid populations (Dr. Michael Banks and Dr. Dennis Hedgecock, University of California at Davis, Bodega Marine Lab, Bodega, California, pers. comm.). Therefore, management alternatives designed to isolate CNFH operations from Battle Creek’s fish populations under a restoration scenario should strive to prevent any future hybridization of chinook salmon runs.

Restoring Wild Fall- and Late-Fall-Run Chinook and Steelhead

Given that large numbers of hatchery-produced fall- and late-fall-run chinook, and steelhead, currently return to Battle Creek, it will be a challenge to restore self-sustaining wild populations of these runs that are independent from CNFH. For example, hatchery-produced steelhead are able to pass upstream of the CNFH barrier dam suggesting that naturally spawning steelhead in Battle Creek are likely linked to the hatchery population. Likewise, the spawning of fall- and late-fall run is now largely confined to the lower 5 miles of Battle Creek including 3 miles of the some of the best spawning habitat in the watershed, suggesting that until/unless this situation is changed, naturally-reproducing populations will continue to be linked with hatchery production. Management alternatives for restoration of lower Battle Creek will need to consider how to isolate hatchery and wild populations of fall- and late-fall-run chinook, and steelhead, in order to establish unique wild runs of these salmonids and to achieve true "restoration" of wild populations.

Disease Management and the Distribution of Infected Adult Salmon

The incidence of Infectious Hematopoietic Necrosis Virus (IHN) in fall-run and late-fall-run chinook salmon produced at CNFH is high[12] and the amount of the virus in individual late-fall-run chinook is also high (presentation by Scott Foott, USFWS, at a meeting to CNFH Production Committee, 1996). Concern for the transmission of IHN from spawning or dead fall- and late-fall chinook salmon to CNFH water supply has been so high that several major management actions intended to prevent this transmission have been implemented. These measures include stopping the upstream migration of fall-run and late-fall-run chinook at the barrier dam (Ward and Kier 1999), installation of an ozonation facility at the CNFH, and further protecting CNFH water supply by the proposed construction of dual-purpose tailrace connectors at hydroelectric facilities in the Battle Creek watershed which shift the de-facto water supply intake site in the Coleman Canal as far upstream as Inskip Diversion dam (Table 2).

Many other diseases that can be transmitted by dead or dying salmon include Whirling Disease (*Myxobolus cerebralis*). Whirling Disease has been documented at CNFH when an outbreak occurred in steelhead in 1984 but has not been detected at CNFH since 1989 (Daniel Free, National Marine Fisheries Service, Santa Rosa, California, pers. comm.). Salmon carcasses can perpetuate Whirling Disease if the oligochete hosts (*Tubifex tubifex*) is present. Although the ability of these host worms to survive in Battle Creek has not been studied (Dr. Ron Hedrick, University of California, Davis, California, pers. comm.) it is likely present (Steve Roberts, Washington Department of Fish and Wildlife, Spokane, Washington, pers. comm.).

Large populations of spawning fall-run chinook salmon in recent years have generated large amount of carcasses which may pose a disease threat to naturally-spawning populations of salmonids in Battle Creek under restoration scenarios. Given the average population size of 27,000 fall-run since 1987, and assuming that each fall-run adult weighs 13 pounds, then an average of 175 tons of carcasses, not including those of late-fall-run chinook, are deposited

[12] The incidence of IHN ranged from 46 to 80 percent in fall-run and 71 to 100 percent in late-fall-run chinook salmon in yearly samples taken in 1992 through 1995 (presentation by Scott Foott, USFWS, at a meeting to CNFH Production Committee, 1996).

annually into the lower five miles of Battle Creek. This unnaturally dense concentration of spawners and carcasses in lower Battle Creek could be an important source of amplification of the IHN virus (Steve Roberts, Washington Department of Fish and Wildlife, Spokane, Washington, pers. comm.) and whirling disease (Dr. Ron Hedrick, University of California, Davis, California, pers. comm.). Concern over disease amplification by carcasses has lead to a policy in Alaska of removing sockeye salmon carcasses (*O. nerka*) from the vicinity of production facilities (Dr. Ted Meyer, Alaska Department of Fish and Game, Juneau, Alaska, pers. comm.) and in Washington, where carcasses are transferred from hatcheries to natural stream systems for nutrient supplementation, a policy stipulates no trans-basin movement of carcasses without testing for specific pathogens (Steve Roberts, Washington Department of Fish and Wildlife, Spokane, Washington, pers. comm.).

The IHN virus can adsorb to organic material in benthic sediment, has been isolated in benthic leeches and mayflies, and can remain infectious for two to three months, and the susceptibility of juvenile salmon to the infection is inversely correlated to age (Dr. Ted Meyer, Alaska Department of Fish and Game, Juneau, Alaska, pers. comm.), suggesting that young winter-run juveniles and spring-run fry, which reside in or emigrate through lower Battle Creek during the time IHN would be viable, could be susceptible to infection from IHN borne by fall- and late-fall-run.

All three pathologists contacted for information in this section clearly pointed out that infection by Whirling Disease or IHN virus does not necessarily mean that fish will become diseased or that diseased fish will necessarily die. Likewise, presence of a pathogen in the water does not necessarily mean that infection will occur. However, all three researchers suggested that maximizing the isolation of hatchery and wild populations is a prudent approach to restoration of Battle Creek salmonids. Furthermore, a low-cost pathogen risk assessment of the Battle Creek watershed capable of detecting viral, bacteriological, and fungal infectious agents was also suggested in light of on going restoration efforts (Dr. Ron Hedrick, University of California, Davis, California, pers. comm.).

Straying of Adults Salmonids to Sacramento River or to Battle Creek

Though the straying of adult fish produced at CNFH to the Sacramento River has not been identified as a problem under existing conditions, at least two alternative management scenarios for the lower Battle Creek watershed introduced in subsequent sections of this report could cause some concerns over straying. Straying of hatchery-produced fish is generally discouraged due to genetic concerns regarding interbreeding between hatchery and wild salmonids. On the other hand, substantial evidence exists that suggest that hatchery and wild fish are disinclined to spawn together due to differences in behavior (Dr. Gabriella Nevitt and Jason Watters, University of California, Davis, California, pers. comm.). Furthermore, some stakeholder groups including sport anglers would likely be pleased if more CNFH-produced fish were induced into remaining in the Sacramento River instead of ascending Battle Creek where fishing regulations are more restrictive.

One suggested alternative management tool, the installation of a weir at the mouth of Battle Creek (to be introduced more fully in subsequent sections), would directly induce CNFH-produced fish to remain in the Sacramento River where they would likely seek out mainstem or tributary spawning habitat. This could be perceived as either a problem or as a benefit by fulfilling the mitigation roles of CNFH of providing more salmon and steelhead for anglers in the Sacramento River. Likewise, another suggested alternative management tool, converting an irrigation ditch (known by the name of the landowner as the "Gover Ditch") to be a direct conduit for salmon and steelhead to emigrate from and return to CNFH in lieu of using lower Battle Creek (to be introduced more fully in subsequent sections), could also lead to increase straying to the Sacramento River of CNFH-produced fish.

The Gover Ditch alternative may also entail additional straying concerns. Presumably, fish reared at CNFH under this scenario, would be imprinted on odors contributed by ozonated Battle Creek water used in CNFH, the CNFH facilities, the Gover Ditch, and the 3.5 miles of the Sacramento River upstream of Battle Creek. Returning adult fish would ideally be attracted back to the Gover Ditch in part by olfactory cues of the Sacramento River upstream of Battle Creek and by releasing hatchery effluent from the Gover Ditch. Several factors might prompt returning hatchery-reared adults to stray into Battle Creek rather than choosing the Gover Ditch or the Sacramento River including familiar odors in Battle Creek, the fact that they would encounter Battle Creek before the Gover Ditch, the greater discharge of Battle Creek compared to the Gover Ditch (but not compared to the Sacramento River), and that Battle Creek might be a more suitable temperature than the Sacramento River or the Gover Ditch.

Exploratory discussions with several experts on the homing and straying of Pacific salmon, suggests that the majority of fish released from the Gover Ditch would return there but that many could be falsely attracted to Battle Creek or stray to the Sacramento River (references for each example documented in footnotes). Two researchers suggested that introducing natural or artificial chemicals to CNFH-reared fish, in addition to the many chemicals fish are currently exposed to during the course of their residence at CNFH, could increase the olfactory uniqueness of the CNFH environment and improve homing rates to CNFH. Several relevant case examples are highlighted here:

- <u>Naselle and Elwha River Hatcheries</u>[13] – These two hatcheries obtain river water from upstream of the hatchery and discharge effluent back to the home river, much the same way that CNFH currently operates on Battle Creek. About 75 percent of coded-wire tagged fall chinook released from the Naselle Hatchery are recaptured in the hatchery with the rest returning to the river. Greater than 99 percent of coded-wire tagged fall chinook released from the Elwha River Hatchery are recaptured in the hatchery and the rest in the river.
- <u>Humptullips Hatchery</u>[13] – This hatchery is located on a tributary to the Humptullips River, immediately upstream of the confluence with the river, and releases its fish to that tributary, but it receives its water supply from the river, in a situation similar to the Gover Ditch alternative. At this hatchery, greater than 95 percent of coded-wire tagged fall chinook return faithfully to the hatchery rather than returning to the Humptullips River, the source of the hatchery's water supply and the stream with the greater discharge.

[13] Information about Washington State fish hatcheries was provided by Vander Haegen and Doty (1995), Howard Fuss, Washington Department of Fish and Wildlife, Olympia, Washington, pers. comm., and Geraldine Vander Haegen, Washington Department of Fish and Wildlife, Olympia, Washington, pers. comm.

- University of Washington Hatchery[14] – Chinook salmon homing/survival rates from release as fry to escapement to the hatchery have been on the order of 4 percent, a very high rate. Similarly, documented straying of University of Washington hatchery fish to other regional streams was shown to be much lower than stray rates of natural populations[15]. A possible reason for these high homing rates and low straying rates is that the facilities at the University of Washington hatchery impart a unique olfactory cue despite the fact that the water supply intake (from an urban ship canal) is only 20 meters upstream of the fish ladder to the hatchery and the entire plumbing system of the hatchery is less than 100 meters in length. Confounding factors include the use of some city and well water in the hatchery and the lack of other nearby streams to distract homing fish.

Straying rates under alternative management scenarios will be hard to predict and have unknown consequences. Any potential management scenario needs to be examined for potential positive and negative impacts of straying on fish populations in the Sacramento River and tributaries, and must be examined for its potential to isolate CNFH stocks from Battle Creek.

Issue: Release of CNFH-Produced Juvenile Salmonids to Battle Creek

USFWS (1993, 1996, 1998a) have identified predation, disease transmittance, competition/displacement, and alteration of migratory responses as ways that juveniles released from CNFH may impact natural populations to be restored in Battle Creek. Other authors have also suggested that decreased genetic fitness through adaptation to hatchery environments or mixing between hatchery and wild stocks (e.g. Berejikian 1995, Berejikian et. al. 1996) could also be a problem for juveniles reared at CNFH. The actual extent of these impacts at CNFH is largely unknown (USFWS 1993, 1996, 1998a), and though these documents speculate that impacts on winter-run chinook from predation, competition, migratory displacement, and disease transmission associated with CNFH are minimal or non-existent, these conclusions were not based on completed investigations. Furthermore, these studies were focused primarily on impacts to winter-run chinook; impacts to all runs of chinook and steelhead, including ESA-listed stocks such as winter- and spring-run and steelhead, need to be evaluated in order to make proper management decisions under restoration scenarios in Battle Creek. Studies specifically designed to evaluate these potential impacts of CNFH operations have not been completed to date for winter-run, nor for the three other chinook stocks or steelhead. Furthermore, conclusions in these three documents that suggested minimal impact of CNFH operations on naturally-produced fish were derived during a period when Battle Creek populations of chinook salmon and steelhead were depressed (USFWS 1998a). As restoration of Battle Creek salmonid populations proceeds, increased interactions between CNFH operations and natural fish populations are expected, suggesting that more investigation of possible impacts is required.

[14] Information about the University of Washington fish hatchery was provided by Dr. Tom Quinn, University of Washington, Seattle, Washington, pers. comm., and Dr. Gabriella Nevitt, University of California, Davis California, pers. comm.

[15] About 0.16% of coded wire tagged coho and chinook salmon from the Issaquah Creek hatchery entered the University of Washington hatchery while only 0.04% of the University fish were collected in Issaquah Creek.

An evaluation of the potential impacts of juvenile releases from CNFH is forthcoming (Jim Smith and Scott Hamelberg, USFWS, Red Bluff, California, pers. comm.). We defer identification of specific issues until the anticipated release of this evaluation later in 1999. Issues raised by this evaluation would also need to be applied to the decision matrix, described in a subsequent section of this report, that will be used to evaluate alternative management strategies for separating CNFH impacts from populations of naturally-produced fish in Battle Creek.

Introduction to Alternative Management Scenarios

The following section introduces possible alternative management scenarios for lower Battle Creek that have been suggested by one or more members of the BCWG as possible ways to isolate the impacts of CNFH from populations under restoration in Battle Creek. This list does not include the full universe of possible alternatives and is merely intended as an aid to the future identification and prioritization of alternative management scenarios within a collaborative process made up of stakeholders and responsible resource agencies from the BCWG and elsewhere. This list is intended to be applied in the decision matrix, to be introduced in the next section, that could serve the as-yet unidentified collaborative body in deciding the direction of fisheries management in the lower Battle Creek watershed. This list of alternatives purposefully avoids suggesting "pros" and "cons" of these alternatives, because an exhaustive analysis of the benefits and challenges of these alternatives needs to be done by the collaborative body. Alternatives listed in this section that have been documented elsewhere are discussed in less detail than those alternatives which have not been developed in other publications. In this report, the amount of documentation of a given alternative is not intended to reflect any preference or aversion for that alternative.

Economic Costs and Benefits

All possible alternative management scenarios will, obviously, have varying economic costs and benefits. Specific costs and benefits for any management alternative will need to be evaluated later after individual alternatives have been more closely developed. Therefore, we have only introduced cost estimates for alternatives where those estimates, and the specific actions themselves, have been carefully developed in recent months (e.g. Table 2 and the alternative for modifying the CNFH barrier dam, presented below).

However, it is important to note that an analysis of the value of various restoration alternatives is in progress by the USBR and will soon be available for future restoration planning (Kreg McCollum, RMI, Sacramento, California, pers. comm.). This study, an "Analysis to Realize the Full Potential of Current Restoration Investments," will evaluate the marginal cost of restoring fish to the upper Sacramento River and Battle Creek including $326 million[16] to achieve a target of 126,000 salmonids in the mainstem Sacramento River, $27 million of public

[16] The total of $326 million is based on estimates of $80 million for the Shasta Temperature Control Device, $10 million for improvements to the ACID diversion dam, $3 million for modifications to the Keswick Fish Trap and stilling basin, $150 million for restoration of Iron Mountain Mine (which could eventually reach as high as $300 million), $75 million for fixes at Red Bluff Diversion Dam, and $8 million for restoration of Clear Creek.

funds to restore fish populations to Battle Creek, and about $30 million spent on recent upgrades to CNFH and an annual operational cost of about $2 million to ensure a return of 30,000 spawning salmonids. These substantial investments all need to be considered when determining the value of and possible impacts from future restoration efforts.

Alternative: Continue Existing Conditions

The abundance and distribution of salmon and steelhead populations in Battle Creek has been artificially managed by the operation of a large, permanent fish barrier dam at CNFH since 1952 (CDFG 1951). Prior to that time, adult salmon were collected from Battle Creek at seasonally installed racks at the historic Battle Creek Hatchery (USFWS 1957). The existing permanent dam has a fish ladder that is closed to create a migration barrier during certain seasons of the year, except when high runoff events (exceeding 350 cfs) make the dam increasingly passable (USFWS 1995b). The mean monthly discharge of Battle Creek at CNFH during the December to March period ranges between 559 to 727 cfs (Figure 4) indicating that, on average, some passage is possible when the ladder is closed. The CNFH has always had a functioning fish passage facility that is left open for at least the period April through June, the principal migration period for spring-run.

Under this alternative, operation of the barrier dam and related fish ladder and monitoring facilities could be modified primarily by changing the schedule that the fish ladder at the barrier dam is open for fish passage into the watershed upstream of CNFH. This alternative implies that no significant structural changes at the barrier dam would be made to assist fish management.

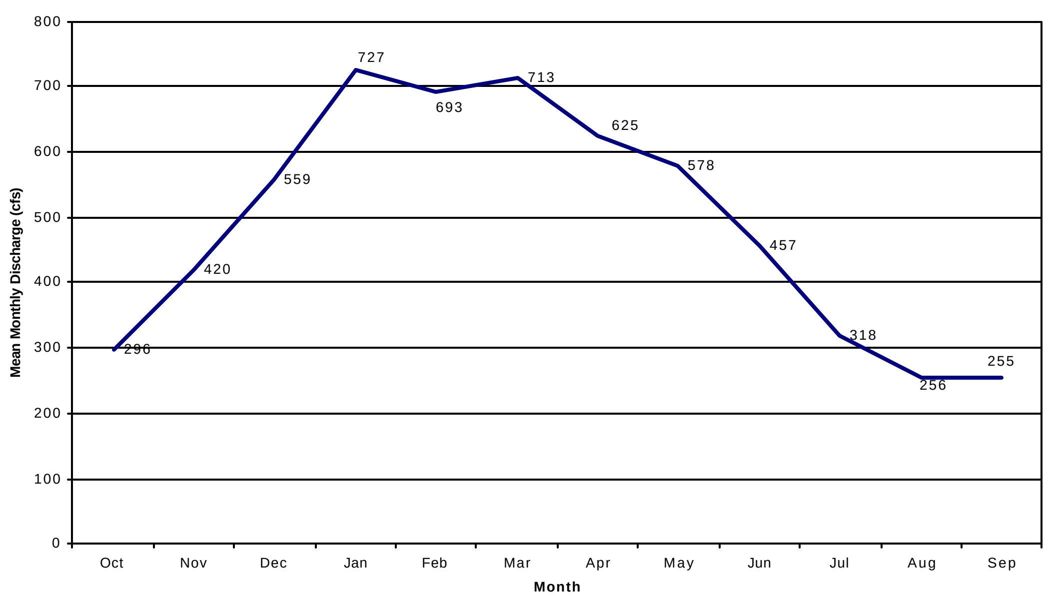

Figure 4. Annual hydrograph for Battle Creek illustrating impaired flows downstream of the Coleman National Fish Hatchery, 1962 to 1994.

Alternative: Modify the CNFH Barrier Dam

A proposal that called for improvements to the CNFH barrier dam was submitted to CALFED by the USFWS and other members of the BCWG in January 1999, and was subsequently rejected, though CALFED invited submission of a revised proposal. These improvements would have included rebuilding the entire dam and fish ladder complex and ranged in cost from $1.4 million to $2.2 million. Alternatively, construction of a removable drop-in barrier was proposed which would be used to seasonally restrict fall-run chinook salmon that may ascend the barrier dam under higher flow conditions in the case that funding could not be secured for rebuilding the dam. The drop-in barrier was priced at about $167,000. The USFWS and other members of the BCWG intend to revise this proposal and submit it by the April 16, 1999 CALFED proposal deadline.

In addition to the facility upgrades proposed by the BCWG to CALFED, accessories to barrier dam modifications have been identified which may be able to improve fish management in Battle Creek. As noted above, in the issues section, managing fish access to the Battle Creek watershed at the barrier dam can be difficult based on the inability to consistently identify seasonal stocks of chinook salmon and the inability to easily distinguish between hatchery and wild chinook salmon. Members of the BCWG have explored the possibility of using automatic sorting machines to distinguish between tagged hatchery fish and untagged hatchery and wild fish. To be fully effective this system would be dependent on tagging 100 percent of all fish released from the hatchery. Engineers from DWR and USFWS have briefly considered such a sorting system and anticipate that it would also require upgrades to the hatchery fish ladder, construction of a sorting facility, and construction of a channel to return fish from the sorting facility to Battle Creek. These facility upgrades were initially estimated to cost as much as $3 million (DWR unpubl.).

Alternative: Install a Weir at the Mouth of Battle Creek

Installation of a seasonal, removable weir at the mouth of Battle Creek would assist the management of adult salmonids entering the Battle Creek watershed. Its primary benefits would be to reduce over saturation of spawning habitat with hatchery-origin fish and may increase fishing opportunities (NMFS 1999).

Alternative: Connect CNFH to Sacramento River with Ditch

Two existing irrigation ditches divert water from Battle Creek in the vicinity of CNFH and flow to the Sacramento River. Under this alternative, one of these ditches would be used as a conveyance facility for CNFH effluent, hatchery-released juvenile fish, and returning adult spawners, in order to physically separate CNFH operations from Battle Creek and link them directly to the Sacramento River.

The Gover Ditch diverts about 75 cfs of water from the north bank of Battle Creek and flows about 2.5 miles to a location on the Sacramento River about 3.5 miles upstream of the mouth of Battle Creek. The Orwick Ditch diverts water from the south bank of Battle Creek and flows about 6 miles to a location on the Sacramento River about one-half mile downstream of Battle Creek. Though the outfall of the Orwick Ditch might be better located for faithful salmonid homing, the remainder of this description will focus on the possible use of the Gover Ditch because the owner of this ditch has expressed interest in exploring this alternative and because the ditch is shorter and more proximate to CNFH.

Under this alternative scenario, fish would be reared at CNFH and released downstream through the Gover Ditch to the Sacramento River. During the time that hatchery-produced salmonids are expected to return to CNFH, all CNFH effluent would be released down the ditch to convey returning adult salmonids to the hatchery and to isolate in the Gover Ditch olfactory attractants on which CNFH salmonids would presumably be imprinted. A fish ladder installed at the outflow of the Gover Ditch would assist returning adult salmonids to ascend into the ditch. This scenario could result in little or no extra water being diverted from Battle Creek as water use by the CNFH and the Gover Ditch are approximately equal. However, extra water might need to be diverted from Battle Creek if a schedule could not be developed that would safely accommodate both fish passage and irrigation. The ditch could be dewatered when not in use by hatchery operations for cleaning and maintenance. Modifications to the ditch might be necessary to facilitate hatchery operations or to assist the possible dual-use of this ditch for irrigation and hatchery use, if a schedule could not be developed that would accommodate both uses.

Alternative: Decrease Production at CNFH

A way to minimize the impacts of CNFH operations on populations of salmonids under restoration in Battle Creek is to decrease the amount of fish produced at CNFH. Though this alternative would not stop all hatchery impacts on wild fish, many of the issues identified in this document would be ameliorated by reduced production. However, production at CNFH is obliged to meet strict mitigation goals. Any benefits to wild fish stemming from a decrease in production would have to be weighed against possible violation of these mitigation requirements.

Alternative: Move Late-Fall-Run and Steelhead Production to Livingston Stone Hatchery

The production of winter-run chinook salmon was moved from CNFH to the new Livingston Stone Hatchery at the base of Shasta Dam in 1998. Though this facility is too small to accommodate all the fish currently produced at CNFH, it may be large enough to accommodate production of late-fall-run salmon and/or steelhead which are currently produced at CNFH[17]. Modifications to the Livingston Stone Hatchery would likely be necessary to accommodate production of one or both of these runs. This alternative would do nothing to offset the impacts of fall-run chinook production at CNFH but would completely isolate the impacts of producing mitigation steelhead and late-fall-run chinook from natural populations under restoration in Battle Creek.

[17] Estimates of whether the necessary space exists at the Livingston Stone Hatchery site vary (Tom Nelson, USFWS-CNFH, Anderson, California, pers. comm.; Harry Rectenwald, CDFG, Redding, California, pers. comm.) and should be more closely evaluated when considering this alternative.

Alternative: Move CNFH Operations to a Sacramento River Site

Relocating CNFH facilities to a site on the Sacramento River closer to Shasta Dam is another alternative that has been suggested because such a siting would be more logical considering that CNFH is intended to mitigate for habitat lost in the Sacramento River by the construction of Shasta Dam and because such a siting would effectively isolate all operations at CNFH from Battle Creek (Tom Nelson, USFWS-CNFH, Anderson, California, pers. comm.). Construction of a mitigation hatchery on the Sacramento River has been examined in the past (Needham et al. 1940, 1943; Black 1999). In the late 1980s, this option was reevaluated in a draft of the Upper Sacramento River Fisheries and Riparian Habitat Management Plan (USRFRHAC 1988) but was omitted from the final plan (USRFRHAC 1989), presumably because this option was considered infeasible. Large, stranded economic investments at the present CNFH site and uncertainty regarding water quality at Sacramento River hatchery sites have been cited as reasons that this alternative was rejected in the past (Harry Rectenwald, CDFG, Redding, California, pers. comm.).

Decision Matrix to Assist the Timely Identification of Alternative Management Scenarios That Maximize Compatibility Between Coleman National Fish Hatchery Operations, Management of Lower Battle Creek, and Salmon and Steelhead Restoration

A decision matrix (Table 7) is presented in this section that can act as a template for use in a future collaborative process to identify alternative management scenarios that optimize restoration of fish populations in Battle Creek. The purpose of this matrix is to provide structure for the decision making process by prompting easy evaluation of each alternative in terms of each issue. It is anticipated that additions, subtractions, and prioritization of alternative management scenarios, as well as additions or subtractions to the list of issues, will be undertaken by some future collaborative process made up of stakeholders and responsible resource agencies from the BCWG and elsewhere.

RECOMMENDATIONS

This Compatibility Plan has identified several issues pertaining to operations of CNFH that could impede fish restoration, even after the habitat in the middle watershed is restored. Therefore, the hatchery's operations need to be seriously considered and modified to insure that the significant investments in habitat restoration are not jeopardized. More immediately, preparation of the NEPA documentation for the habitat restoration will be hindered without closure on the hatchery issues. Finally, the proposed construction or physical modification of the CNFH barrier weir should be done under the guidance of a well considered management program. At this point, a comprehensive decision making process has not been under taken to ensure that CNFH operations are compatible with the restoration of salmon and steelhead in Battle Creek. Therefore, we recommend the following actions:

- A facilitated, collaborative process should be undertaken by all interested agencies and stakeholders to refine policies regarding CNFH operations with the intent of maximizing their compatibility with the restoration of salmon and steelhead in Battle Creek.

- Issues identified in this plan, and possibly others, should be evaluated and prioritized.

- Alternative management scenarios for CNFH should be identified and evaluated.

- The decision matrix introduced in this plan should be employed to logically evaluate how possible alternative management scenarios for CNFH address each of the prioritized issues.

- A revised management plan for CNFH should be written that maximizes the compatibility of CNFH operations and the restoration of salmon and steelhead in Battle Creek.

Table 7. Decision matrix to assist the timely identification of alternative management scenarios that maximize compatibility between Coleman National Fish Hatchery operations, management of lower Battle Creek, and salmon and steelhead restoration.

	ALTERNATIVE MANAGEMENT SCENARIOS						
ISSUES	Continue Existing Conditions	Modify the CNFH Barrier Dam	Install a Weir at the Mouth of Battle Creek	Connect CNFH to Sacramento River with Ditch	Decrease Production at CNFH	Move Late-Fall-Run and Steelhead Production to Livingston Stone Hatchery	Move CNFH to a Sacramento River Site
Biological Effectiveness Principle							
Natural Processes Principle							
Biological Certainty Principle							
Economic Costs and Benefits							
Hatchery Bypass Flows							
Hatchery Effluent Water Quality							
Hatchery Effluent Temperature							
Carrying Capacity of Fall-Run Chinook Spawners in Lower Battle Creek							
Decoying Sacramento River Fall-Run Chinook to Battle Creek							
Potential Hybridization at CNFH							
Restoring Wild Fall- and Late-Fall-Run Chinook and Steelhead							
Disease Management and the Distribution of Infected Adult Salmon							
Straying of Adults Salmonids to Sacramento River or to Battle Creek							
Predation by CNFH Juveniles							
Disease Transmittance by CNFH Juveniles							
Competition/Displacement by CNFH Juveniles							
Alteration of Migratory Responses by CNFH Juveniles							
Decreased Genetic Fitness Caused by CNFH Rearing Operations							

LITERATURE CITED

Banks, M.A., V.K. Rashbrook, M.J. Calavetta, C.A. Dean and D. Hedgecock. Submitted. Microsatellite DNA Variation in Chinook Salmon of California's Central Valley. Submitted to Canadian Journal of Fisheries and Aquatic Sciences. Submitted February 1999.

Bay Institute, The. 1998. From the Sierra to the sea: the ecological history of the San Francisco Bay-Delta watershed. The Bay Institute, San Rafael, California.

Berejikian, B. 1995. The effects of hatchery and wild ancestry and experience on the relative ability of steelhead trout fry (*Oncorhynchus mykiss*) to avoid a benthic predator. Can. J. Fish. Aquat. Sci. 52:2476-2482.

Berejikian, B., S.B. Matthews, and T.P. Quinn. 1996. Effects of hatchery and wild ancestry and rearing environments on the development of agonistic behaviour in steelhead trout (*Oncorhynchus mykiss*) fry. Can. J. Fish. Aquat. Sci. 53:2004-2014.Berejikian, B.A. 1995. The effects of hatchery and wild ancestry and experience on the relative ability of steelhead trout fry (*Oncorhynchus mykiss*) to avoid a benthic predator. Can. J. Fish. Aquat. Sci. 52:2476-2482.

Berejikian, B.A., S.B. Matthews, and T.P. Quinn. 1996. Effects of hatchery and wild ancestry and rearing environments on the development of agonistic behaviour in steelhead trout (*Oncorhynchus mykiss*) fry. Can. J. Fish. Aquat. Sci. 53:2004-2014.

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.

Black, M. 1999. Shasta salmon salvage efforts: Coleman National Fish Station on Battle Creek, 1985- 1992. Prepared for the Battle Creek Working Group by Kier Associates under contract with Metropolitan Water District of Southern California, with additional funding provided by USDI, Bureau of Reclamation, Shasta Lake, California. Sausalito, Ca. 125 pp.

CDFG (California Department of Fish and Game). 1951. Memorandum dated November 2, 1951 regarding handling of fish at Coleman hatchery signed by Donald Fry. On file at CDFG, Redding, California.

CDFG (California Department of Fish and Game). 1965a. Letter to George Kohn from R.J. O'Brien, CDFG, regarding U.S. Army Corps of Engineers streambank protection work, April 20, 1965. On file at CDFG, Redding, California.

CDFG (California Department of Fish and Game). 1965b. Memorandum to the files from R.J. O'Brien, CDFG, summarizing information on streambed alterations in lower Battle Creek, April 22, 1965. On file at CDFG, Redding, California.

CDFG (California Department of Fish and Game). 1965c. Memorandum to R.J. O'Brien, CDFG, from T.P. Healey, CDFG, regarding Army Corps of Engineers Project in Battle Creek, April 16, 1965. On file at CDFG, Redding, California.

CDFG (California Department of Fish and Game). 1967a. Memorandum to Chief of Marine Resources Branch, CDFG, from E.P. Hughes, CDFG, regarding spawning gravel acquisition in Battle Creek, April 7, 1967. On file at CDFG, Redding, California.

CDFG (California Department of Fish and Game). 1967b. Memorandum to Deputy Director of CDFG from R.J. Nesbitt, Wildlife Conservation Board, regarding acquisition of spawning gravel in lower Battle Creek, May 15, 1967. On file at CDFG, Redding, California.

CDFG (California Department of Fish and Game). 1967c. Memorandum to Deputy Director of CDFG from John Radovich, CDFG, regarding acquisition of spawning gravel in lower Battle Creek, June 14, 1967. On file at CDFG, Redding, California.

CDFG (California Department of Fish and Game). 1969a. Memorandum to Chief of Operations from R.J. O'Brien on October 7, 1969. On file at CDFG, Redding, California.

CDFG (California Department of Fish and Game). 1969b. Minutes of the Coleman National Fish Hatchery water allotment, fish planting, and fish screen meeting, September 22, 1969 attached to a letter from R.J. O'Brien, CDFG, to Tom Luken, USFWS, dated October 7, 1969. On file at CDFG, Redding, California.

CDFG (California Department of Fish and Game). 1980. Letter to David Kitayama from Charlie Fullerton, CDFG, regarding streambed alteration in lower Battle Creek, December 8, 1980. On file at CDFG, Redding, California.

CDFG (California Department of Fish and Game). 1993a. Final report - Battle Creek spawning restoration project. CDFG, Sacramento, California.

CDFG (California Department of Fish and Game). 1993b. Restoring Central Valley streams: A plan for action. California Department of Fish and Game.

CDFG (California Department of Fish and Game). 1995c. Internal memorandum from Dave Hoopaugh to Harry Rectenwald on January 10, 1995. On file at CDFG, Redding, California.

CDFG (California Department of Fish and Game). 1997a. Letter to Jim Smith, USFWS, from Richard Elliot, CDFG, concerning operation of a fish trap at the CNFH barrier dam, dated March 24, 1997. On file at CDFG, Redding, California.

CDFG (California Department of Fish and Game). 1997b. Letter to Dick Jewell, USFWS, from Richard Elliot, CDFG, concerning the CNFH water supply system draft environmental assessment, dated April 18, 1997. On file at CDFG, Redding, California.

CDFG (California Department of Fish and Game). 1998. Letter to Jim Smith, USFWS, from Richard Elliot, CDFG, concerning the proposed reevaluation of CNFH, dated January 16, 1998. On file at CDFG, Redding, California.

Coots, M. and T. Healey. 1966. Pacific Gas and Electric Company's Battle Creek System Power Project, Minor Part, License Number 1121. CDFG. 31pp.

Cope, O. B., and D. W. Slater. 1957. Role of Coleman Hatchery in maintaining a king salmon run. US Department of the Interior Fish and Wildlife Service Research Report 47:1-22.

DEFT (Diversion Effect on Fisheries Team). 1998. DEFT Evaluation: Upstream ecosystem restoration benefits for chinook salmon. Revised draft for subgroup review, dated October 5, 1998.

Hilborn, R. 1992. Hatcheries and the future of salmon in the Northwest. Fisheries 17(1):5-8.

Kitayama, D. 1980. Letter to Director, Coleman Hatchery, from David Kitayama, California Trout, questioning the practice of grading Battle Creek between its mouth and Coleman Hatchery, circa November, 1980. On file at CDFG, Redding, California.

Klug, W.S. and M.R. Cummings. 1993. Essentials of genetics. McMillan Publishing Company, New York, New York. 513 pp. plus appendices.

National Fish Hatchery Review Panel. 1994. Report of the National Fish Hatchery Review Panel. Prepared for USFWS and funded by the National Fish and Wildlife Foundation in partnership with several organizations.

Needham, P.R., H.A. Hanson, and L.P. Parker. 1943. "Supplementary report on investigations of fish-salvage problems in relation to Shasta Dam. Spec. Sci. Rept. No. 26. Fish and Wildlife Service.

Needham, P.R., O.R. Smith, and H.A. Hanson. 1940. Salmon salvage problems in relation to Shasta Dam, California and notes on the biology of the Sacramento River salmon. Transactions of the American Fisheries Society, Toronto, Canada, September 5–6 , 1940. Pp. 55-69.

NMFS (National Marine Fisheries Service). 1999. Letter to Bill Karr, Western Outdoor News, from William T. Hogarth, NMFS, regarding hatchery management practices at Coleman National Fish Hatchery, February 1, 1999. NMFS, Long Beach, California.

NORCAL (NORCAL Fishing Guides and Sportsmen's Association). 1999. Letter to U.S. Department of Fish and Wildlife [sic], from W.B. "Scott" Ferris, NORCAL, regarding euthanization of salmon fry, February 19, 1999. NORCAL, Anderson, California.

Quinn, T.P. 1997. Homing, straying and colonization. *In* Genetic effects of straying of non-native hatchery fish into natural populations. NOAA Tech. Memo. NMFS-NWFSC-30, NMFS, Seattle, Wa.

Rahr, G.R., III, J.A. Lichatowich, R. Hubley, and S.M. Whidden. 1998. Sanctuaries for native salmon: A conservation strategy for the 21st Century. Fisheries. 23(4):6-7 and 36.

SBFC (State Board of Fish Commissioners). 1896. Biennial Reports 1895-1896. State Board of Fish Commissioners. A.J Johnson, Superintendent State Printing, Sacramento.

Smouse, PE, and Chevillon, C. 1998. Analytical aspects of population-specific DNA fingerprinting for individuals. Journal of Heredity. 89**:**143-150.

Steward, C.R. and T.C. Bjornn. 1990. Supplementation of salmon and steelhead stocks with hatchery fish: a synthesis of published literature. The. Rep. No. 90-1. Bonneville Power Administration, Portland, Oregon.

TRPA (Thomas R. Payne and Associates). 1998. A 1989 instream flow study: 1 of 8 components. Prepared for California Department of Fish and Game.

USACE (U.S. Army Corps of Engineers). 1971. Letter to Travis Roberts, USFWS, from James Donovan, U.S. Army Corps of Engineers, regarding flood control work in lower Battle Creek, March 19, 1971. On file at CDFG, Redding, California.

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 (U.S. Fish and Wildlife Service). 1957. Role of Coleman Hatchery in Maintaining a King Salmon Run. Research Report 47. 22pp.

USFWS (U.S. Fish and Wildlife Service). 1971. Letter to District Engineer, U.S. Army Corps of Engineers, from Travis Roberts, USFWS, regarding flood control work in lower Battle Creek, March 3, 1971. On file at CDFG, Redding, California.

USFWS (U.S. Fish and Wildlife Service). 1987. Coleman National Fish Hatchery station development plan. U. S. Fish and Wildlife Service, Region One.

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). 1995b. Report of escapement of hatchery origin winter chinook salmon to the Sacramento River in 1995. As included in Application for a Permit to Enhance Propagation Survival of Endangered or Threatened Species Under the Endangered Species Act - Coleman National Fish Hatchery Winter Chinook Salmon Propagation Program 1995.

USFWS (U.S. Fish and Wildlife Service). 1996. Biological assessment on the effects of Coleman National Fish Hatchery operations on winter-run chinook salmon. Prepared by the U.S. Fish and Wildlife Service, Red Bluff, 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). 1998a. Project description and brief impact assessment of fish propagation activities conducted at Coleman and Livingston Stone National Fish Hatcheries. USFWS, Red Bluff, California.

USFWS (U.S. Fish and Wildlife Service). 1998b. USFWS position paper on the Battle Creek watershed. USFWS , Sacramento, California. April 3, 1998.

USFWS (U.S. Fish and Wildlife Service). 1999a. Letter of commendation to Dr. Michael Black, Kier Associates, from James Smith, USFWS, regarding Dr. Black's historical analysis of Coleman National Fish Hatchery, February 4, 1999. USFWS, Red Bluff, California.

USFWS (U.S. Fish and Wildlife Service). 1999b. Proposal to improve passage and the barrier weir: response to CALFED solicitation. USFWS Red Bluff, California.

USFWS (U.S. Fish and Wildlife Service). 1999c. Comments on the draft report "Maximizing Compatibility Between Coleman National Fish Hatchery Operations, Management of Lower Battle Creek, and Salmon and Steelhead Restoration" prepared by Kier Associates, March 30, 1999. USFWS Red Bluff, California.

USFWS (U.S. Fish and Wildlife Service). n.d.. Draft: Site and interpretive development for Coleman National Fish Hatchery and Battle Creek Wildlife Area. USFWS Red Bluff, California.

USRFRHAC (Upper Sacramento River Fisheries and Riparian Habitat Advisory Council). 1988. DRAFT: Upper Sacramento River fisheries and riparian habitat management plan, December 1988. State of California Resources Agency.

USRFRHAC (Upper Sacramento River Fisheries and Riparian Habitat Advisory Council). 1989. Upper Sacramento River fisheries and riparian habitat management plan. State of California Resources Agency. 158 p.

SBFC (State Board of Fish Commissioners). 1896. Biennial Reports 1895-1896. State Board of Fish Commissioners. A.J Johnson, Superintendent State Printing, Sacramento.

Steward, C.R. and T.C. Bjornn. 1990. Supplementation of salmon and steelhead stocks with hatchery fish: a synthesis of the published literature. *in*: W.H. Miller, ed. Analysis of salmon and steelhead supplementation. Technical Report 90-1. Bonneville Power Administration, Portland, Oregon.

Vander Haegen, G. and D. Doty. 1995. Homing of coho and fall chinook in Washington. Washington Department of Fish and Wildlife, Tech. Rept. H95-08. Olympia, Washington.

Ward, M.B. and W.M. Kier. 1999. 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.

United States Department of the Interior

FISH AND WILDLIFE SERVICE

NORTHERN CENTRAL VALLEY FISH AND WILDLIFE OFFICE
10950 Tyler Road
Red Bluff, CA 96080
Phone: 530 527-3043
FAX: 530 529-0292

23 April 1999

William M. Kier Associates
207 Second Street, Suite B
Sausalito, CA 94965

Dear Mr. Kier:

We have reviewed the draft document entitled "Maximizing Compatibility Between Coleman National Fish Hatchery Operations, Management of Lower Battle Creek, and Salmon and Steelhead Restoration." The document reflects a great deal of thought and research effort. We concur that the approach of this initial "Compatibility Plan" should be to objectively explore and present all reasonable alternative scenarios in regard to co-managing natural and hatchery production in Battle Creek. However, we suggest substantial modification to this document, so that all reasonable options for co-managing these fish stocks are considered and presented.

The initial approach of this Compatibility Plan should be to objectively explore and present all issues and reasonable alternative scenarios to co-manage natural and hatchery production in Battle Creek. As it is not currently known to what extent operations at Coleman National Fish Hatchery (NFH) will be isolated vs. integrated into restoration actions in Battle Creek, we suggest fully incorporating reasonable ideas from each of these possible strategies. Such an exploration should include analyses of potential risks, benefits, and an indication of the level of uncertainty associated with the various restoration alternatives.

We fully support your recommendation for the development of "A facilitated, collaborative process..." regarding Coleman NFH operations. In fact, this statement is consistent with the Service's desire (April 3, 1998 position paper), which asserts that the Service's goal for Battle Creek is to restore the watershed for naturally-produced anadromous salmonids, while integrating Coleman NFH operations. It is worth mentioning that the collaborative approach for the integration of Coleman NFH operations with Battle Creek restoration has, in fact, been ongoing in regard to a number of facility modifications (e.g., ozone plant construction, water intake system modification, barrier weir/fish ladder modification). Unfortunately, these ongoing activities are hardly acknowledged in the current draft document.

Again, although claiming to promote a "collaborative process" to "refine" Coleman NFH operations for the benefit of anadromous salmonids in Battle Creek, the document also fails to emphasize the overall importance and contribution of the mitigation facility to the entire Central Valley and the Pacific fishery. We feel that in order for the fishery agencies and stakeholders to make an objective analysis of hatchery operations, Battle Creek restoration, and the integration of the two, both sides of the issues need to be presented and considered in the decision making matrix to allow a proper analysis of benefits, issues and alternatives.

We acknowledge that many of the issues identified in the draft document and the decision making matrix deserve investigation. However, the arguments presented in the "Compatibility Plan" section of the document, tend to preempt the "facilitated, collaborative process..." Presenting such a significant conclusion as "isolation" as part of the "preferred alternative" in the opening part of the document (Compatibility Plan section) precludes a full and open discussion of all alternatives. For this reason, it may be more appropriate to restructure the document by presenting the "Technical Plan" section first. Restructuring in this way, may result in an unbiased presentation of issues, alternative management scenarios, and the suggested decision making matrix. Many parts of the "Compatibility Plan" section may be incorporated into the "Technical Plan" section as supportive materials to better describe some of the issues or alternative management scenarios. A restructuring of the document in this manner will provide readers a more unbiased view of the situation at hand, leading to the development of a successful "Compatibility Plan."

Also, as stated in the document, the Service reiterates that lists of issues and alternatives be considered "incomplete" at this time and warrant further discussion before the "decision matrix" is finalized. Once all the issues and potential alternatives are identified, through the collaborative process, decisions should be made to establish whether an isolation or an integration approach should be accepted.

As mentioned at previous Battle Creek Working Group meetings, the Service is embarking on a Coleman National Fish Hatchery "Reevaluation" process. Recall that the Reevaluation process is intended to identify benefits of the hatchery in terms of contribution to the fishery resource and clearly define fish production objectives as they pertain to mitigation responsibilities. Additionally, potential risks resulting from activities conducted at Coleman NFH on the natural production of listed or proposed anadromous salmonids, will be identified through this process.

Management alternatives are also expected to be recommended where impacts are identified. We believe the information and documentation generated as part of the Reevaluation process is critical to the development of a final "Compatibility Plan."

In addition to the comments suggesting a restructuring of the document, we also have a number of comments to offer which are more technical in nature. At this time, however, we refrain from fully developing those comments, as: 1) more information is expected to be forthcoming through the Reevaluation process, and, 2) if the current draft document is restructured, they may no-longer be applicable.

Please feel free to contact me if you have any questions regarding these comments, or if I can provide additional information.

Sincerely,

James G. Smith
Project Leader

Date: Tue, 27 Apr 1999 22:01:53 -0400
From: Harry Rectenwald <103424.2422@compuserve.com>
Subject: Coleman Hatchery Compatibility Report.
Sender: Harry Rectenwald <103424.2422@compuserve.com>
To: Mike Ward <wardski@televar.com>

Mike-

Several biologists in the Department of Fish and Game have reviewed the draft report titled "Maximizing Compatibility Between Coleman National Fish Hatchery Operations and Management of Lower Battle Creek, Salmon and Steelhead Restoration". The reviewers comments support the general innovative approach adopted in the report and the recommendations to further investigate promising measures to maximize the compatibility. The recommended approach of isolating the effects of hatchery operations from natural populations of salmon and steelhead in Battle Creek supports endangered species recovery and restoration of other depleted populations. This isolation approach is consistent with recent US Fish and Wildlife actions and expenditures, including the ozonation project and the Livingstone Stone satellite hatchery, as well as the established role of the hatchery which is specific to the Sacramento River and not Battle Creek.

Please reference the following Department of Fish and Game correspondence as supporting the isolation approach as the best way to integrate or make the hatchery more compatible with the restoration of the Battle Creek fisheries and ecosystem:

a) Comment Letter on the US Fish and Wildlife Service Proposed Reevaluation of Coleman Hatchery dated January 16, 1998.

b) Comment Letter on the US Fish and Wildlife Service Draft Environmental Assessment addressing the Coleman Hatchery Ozone Project. dated April 18, 1997.

The previous Kier and Associates Report titled " Shasta Salmon Salvage Efforts: Coleman National Fish Hatchery on Battle Creek 1895-1992" began as an effort to clarify the role of Coleman Hatchery in more precise terms than general Shasta Dam compensation. The role of the hatchery still seems to be rather dynamic. It would be very helpful to have further collaborative efforts at maximizing the compatibility of Coleman Hatchery operation with the Battle Creek ecosystem. In addition, it will be necessary at some point to define the role of the hatchery with the completion of all the restoration items for the upper Sacramento River and the attainment of the restoration goals for natural production (see the conclusion of the SB 1086 Draft Report that once considered expanding hatchery production in the upper Sacramento River but deferred the decision until restoration of natural production was better understood).

The report could use more discussion on the general attributes of the lower reach of Battle Creek. Please refer to the descriptions in the proposed reforestation of lower Battle Creek.

Thank you for your thorough research and objective analysis on this complex topic.

Harry Rectenwald