Further Biological Analyses for Information Presented at the Public Meeting Held in Red Bluff, California, on March 15, 2004, Regarding the Differences between the Five Dam Removal Alternative and the Eight Dam Removal Alternative

Prepared for:

Battle Creek Salmon and Steelhead Restoration Project
Project Management Team

For Submittal to:
California Bay- Delta Authority (CBDA) Ecosystem Restoration Program Sub-committee

Prepared by:

California Department of Fish and Game
601 Locust Street
Redding, CA 96001
Contact: Harry Rectenwald
Ph: (530) 225-2368 Fax: (530) 225-2381

May 2004

California Department of Fish and Game. 2004. *Further biological analyses for information presented at the public meeting held in Red Bluff, California, on March 15, 2004, regarding the differences between the five dam removal alternative and the eight dam removal alternative*. Prepared for the Battle Creek Salmon and Steelhead Restoration Project, Project Management Team. May. Redding, CA.

Further Biological Analyses for Information Presented at the Public Meeting Held in Red Bluff, California, on March 15, 2004 regarding the Differences between the Five Dam Removal Alternative and the Eight Dam Removal Alternative

Introduction and Purpose

On March 15, 2004, a public meeting was held to discuss environmental benefits associated with the proposed alternative for the Battle Creek Salmon and Steelhead Restoration Project (i.e., Five Dam Removal Alternative, as described in the 1999 Memorandum of Understanding and the July 2003 Draft Environmental Impact Statement/Environmental Impact Report [EIS/EIR]) and a newly developed scenario that removes three more dams than the proposed project (i.e., Eight Dam Removal Alternative, also known as Alternative B). The meeting also presented uncertainties associated with the schedule and process impacts associated with implementing the Eight Dam Removal Alternative instead of the current proposed action—the Five Dam Removal Alternative. The purpose of the March 15 meeting was to clarify public understanding of the differences between the Five Dam Removal Alternative and the Eight Dam Removal Alternative.

The purpose of this report is to provide follow-up biological analyses for information presented on March 15 regarding the differences between the Five Dam Removal Alternative and the Eight Dam Removal Alternative. The flow and temperature regime for the Eight Dam Removal Alternative was not available in prior documents and was developed in a collaborative effort between the California Hydro Reform Coalition and Project Management Team for the Battle Creek Salmon and Steelhead Restoration Project (Restoration Project). Temperature and flow conditions analyzed in this report are those presented on March 15 and agreed on by participants to constitute the best available depiction of conditions with the removal of eight dams and unimpaired flow conditions without any powerhouses in the project area. Although there was discussion on March 15 of another scenario that would remove all the powerhouses from the project area, this report does not examine that additional scenario. The information used in this analysis is derived from that presented in the Public

Draft EIS/EIR for the Restoration Project and its references. Included in the information sources are the findings of the Greater Battle Creek Watershed Working Group Biological Technical Team, which examined restoration options in an open forum as described in Kier (1998 and 1999).

The Restoration Project targets an assemblage of fish, including four races of Chinook salmon and steelhead. The spring-run and winter-run Chinook salmon and steelhead are priority target species for the Restoration Project under both the Five Dam Removal Alternative and the Eight Dam Removal Alternative.

Project Description

The project area is the same for all alternatives and scenarios analyzed to date, but actions considered at each dam vary. Project components as presented on March 15 are summarized below.

There is a distinct boundary for the 42 miles of Battle Creek in the Restoration Project. On North Fork Battle Creek, the project boundary is several miles above the North Battle Creek Feeder Diversion Dam, at an absolute barrier to fish migration. On South Fork Battle Creek, the boundary is several miles above the South Diversion Dam at Angel Falls. The western boundary for the Restoration Project ends on the mainstem of Battle Creek at Coleman Powerhouse, approximately 9 miles below the confluence of the North and South Forks of Battle Creek.

The Five Dam Removal Alternative includes removal of five dams and one spring collection facility. These include the South Diversion Dam and Coleman Diversion Dam on South Fork Battle Creek; the Soap Creek Feeder Diversion Dam, a spring-fed stream, and Lower Ripley Creek Diversion Dam, which are tributaries to the South Fork; the spring collection facility near Eagle Canyon Dam and Canal, and Wildcat Canal Diversion Dam on North Fork Battle Creek.

Under the Eight Dam Removal Alternative, three additional dams would be removed. The three dams are North Battle Creek Feeder Diversion Dam, Eagle Canyon Dam, and Inskip Dam, which have heights of 8 feet, 15 feet, and 28 feet, respectively.

Some additional operational considerations would result from implementing the Eight Dam Removal Alternative. Under this scenario, the only remaining diversion facilities would be in the upper North Fork Battle Creek watershed, including Al Smith and Keswick Diversion Dams and Lake Grace and Lake Nora Forebays. There would no longer be any diversions on the South Fork. All water (less spill) would be diverted on the North Fork (flows greater than 3 cfs) above the Restoration Project area and would be diverted into Al Smith to Keswick Canals and then run through Volta and Volta 2 powerhouses, finally dropping into Cross Country Canal. This would be the only source of water for

the entire power system. Operationally, this would mean that if any of the remaining canals (Cross Country, Inskip, or Coleman) were to be shut down for either maintenance or an emergency, there would be no other means for diverted water to enter or leave the system.

Aside from the physical differences between the Eight Dam Removal Alternative and the Five Dam Removal Alternative, one major difference is the Adaptive Management Plan (AMP). The AMP directs monitoring and the study of environmental changes along Battle Creek and is funded to make adjustments to management practices as necessary. Under the Five Dam Removal Alternative, the AMP is stipulated in the Memorandum of Understanding (MOU) for the Restoration Project, which can be found in Appendix A of the Draft EIS/EIR (Jones & Stokes 2003). The AMP also meets requirements put forth by the California Bay Delta Authority Science Panel. Another feature of the AMP under the Five Dam Removal Alternative is that it has an Adaptive Management Fund (AMF) that would provide funds for some of the management changes that may be required.

The AMP also includes a Water Acquisition Fund (WAF) to allow for adaptively increasing flows as needed, and dedicates those increased flows from dam removal in perpetuity through an State Water Resources Control Board (SWRCB) water rights 1707 dedication to California Department of Fish and Game (DFG) (as provided for under the MOU). The MOU also states that the signing parties will support the flows resulting from the MOU and AMP going into the Federal Energy Regulatory Commission (FERC) relicensing in 2026. Under the current agreement, PG&E would transfer its water rights at removed dams to DFG, with the cost for forgone energy being fixed.

An AMP would also be included under the Eight Dam Removal Alternative. However, this AMP would not have some of the other features present under the Five Dam Removal Alternative, such as the AMF or dedication of water rights, which are specified by the current MOU. For the Restoration Project to proceed with the Eight Dam Removal Alternative, agreements similar to those under the Five Dam Alternative would be necessary. This would require new negotiations of agreements that do not currently exist. For example, there would have to be a new negotiation for additional forgone energy costs that would result from the Eight Dam Removal Alternative. The Five Dam Removal Alternative will amend the FERC license 2 decades prior to its expiration in year 2026. The schedule for an amendment under the Eight Dam Removal Alternative is unknown because of uncertainties in reaching a set of complex financial legal and institutional agreements between the agencies and the Licensee. There are adverse biological consequences of missed opportunities to provide listed species with recovery opportunities sooner rather than later, because of the need for drought-resistant refugia in areas like Battle Creek.

Methods

Sediment Transport

Attachment A contains the geomorphic analysis presented at the March 15 meeting by Mike Roberts of The Nature Conservancy. This geomorphic analysis compares differences in sediment transport between the Eight Dam Removal Alternative and the Five Dam Removal Alternative. The analysis relied on a literature review that included:

- Kondolf and Katzel (1998), who evaluated sediment transport occurring in the Battle Creek watershed using several techniques, including tracer rock studies;
- Greimann (2001), who provided some hydrology information; and
- California Department of Water Resources (DWR 2000) hydrology information used in a report on a fish ladder design.

In addition, independent specialists were contacted for recommendations on how to conduct the geomorphology analysis. These discussions, along with the literature review, identified magnitude and duration of a threshold event as the two main components to the geomorphology analysis. A threshold event occurs when there is enough water moving through a system that it weakens the forces holding gravel in place. Kondolf and Katzel (1998) were fortunate enough to have tracer rocks and a monitoring program in place during a runoff event that actually moved sediment on Battle Creek. Kondolf and Katzel (1998) also evaluated sediment management practices and sediment sluicing through the radial gates at all the dams, as a best management practice for sediment transport.

Temperature Regime

Attachment B contains the SNTEMP (PG&E 2001) temperature model output, showing monthly average water temperature simulations for normal years and extremely dry hot years. The model outputs were done for the months of June, August, and September under the minimum MOU flow in each reach of Battle Creek. The model was used by the Greater Battle Creek Watershed Working Group Biological Technical Team to examine predicted temperature regimes under different weather and runoff conditions. This was done to determine habitat suitability for different species and life stages of salmon and steelhead at appropriate times (Kier 1999). The formation of coldwater refugia was examined using SNTEMP and dilution equation at coldwater inputs for differences between the Eight Dam Removal Alternative and Five Dam Removal Alternative. A temperature simulation was not available for the Eight Dam Removal Alternative in its exact form; however, it was agreed during the collaborative analysis, that a surrogate could be developed using a combination of simulations. Specifically,

for North Fork and mainstem Battle Creek, the analysis used the simulation that included removal of Wildcat and Eagle Canyon Diversion Dams (the presence of North Battle Creek Feeder Diversion Dam was deemed irrelevant in the summer because little to none of the flow is diverted at that time under the Five Dam Removal Alternative). For South Fork Battle Creek, the analysis used the simulation that removed all the dams and powerhouses in the project area. The only limitation was on the mainstem, where the surrogate left out some of the base flow on the South Fork associated with removal of Inskip Dam (approximately 15% of mainstem base flow). The coldwater refugia below Eagle Canyon Dam were estimated by the dilution equation with different mixtures of warmer surface water and cold spring water that comes in below the dam.

Hydrology

The normal year hydrograph was constructed for the Eight Dam Removal Alternative, Five Dam Removal Alternative, Unimpaired Flows, and the No Action Alternative under base flow conditions. The hydrograph was examined for changes in the pattern of seasonality, especially areas of biologic or geomorphic significance. The watershed was examined for the presence of any major storage reservoirs that are capable of altering the hydrograph.

Species Response to Temperature

The temperature response of the primary target species of the Restoration Project was approached using a critical factor analysis similar to that presented in the Battle Creek Salmon and Steelhead Restoration Plan (Kier 1999). The presence and absence of temperature-sensitive life stages in each reach were based on results of life history studies for the nearby Sacramento River and results of trapping and survey estimates on Battle Creek (Table 1) Temperature tolerance varies among species and among life stages in the same species (Figure 1). The analysis focused on the most temperature-sensitive life stages at the most vulnerable times when they are present. If significant differences between the Eight Dam Removal Alternative and the Five Dam Removal Alternative were not apparent in these critical periods, it was deemed reasonable to assume that differences in other periods would not be significant. Survival estimates in response to water temperatures are based on studies reported in the literature and impact analysis techniques used for the same assemblage of fish in the Sacramento River. Temperature response thresholds under different categories of survival and suitability for different life stages of the priority species for the Restoration Project present at especially vulnerable times include:

- The critical months for winter-run Chinook salmon embryos are June through August and September is the critical month for spring-run embryos. These are the months in which the temeperature sensitive embryonic stages are most abundant and high water temperatures occur. These high water

temperatures are expected to cause significant mortality; however, the relative difference between the Five Dam Removal Alternative and the Eight Dam Removal Alternative is assumed to be small. The temperature survival relationships shown in figures in the results section for the Chinook embryos were developed for upper Sacramento River Chinook and used in a similar impact analysis for a temperature control project related to Shasta Dam Removal (USFWS 1990); Reclamation 1991). These temperature mortality relationships were applied to Battle Creek in the Restoration Plan (Kier 1999).

- Spring-run Chinook salmon adult over-summering is examined in August when warm climate conditions occur and adults are reaching the end of their pre-spawning holding period. The temperature tolerances shown on figures in the results section for adults include the preferred temperature range (DWR 1988) and a range where exposure represents stressful conditions as presented in the Battle Creek Restoration Plan (Kier 1999).
- Winter-run Chinook juvenile temperature tolerance is examined in September when this life stage is present and warm climate conditions occur. The temperature responses shown in figures in the results section for juvenile Chinook include lethal temperature range (Brett 1952; Raleigh et al. 1984, Myrick and Cech 2001;) and the preferred temperature range (Groot and Margolis 1991). There is no response indicated in the zone between preferred and lethal because there are considerable variation and confounding factors that include available food supply (Bisson and Davis 1976) and acclimation temperature (Brett 1952).
- Spring-run Chinook salmon and steelhead smolt thermal tolerance is examined in June when the last of these smolt populations are present (USFWS 2001 and USFWS pers. comm. 2004) and warm climate conditions occur. The temperature response indicated in the figures refers to the advanced juvenile life stages of anadromous salmonids when the parr stage transforms to a smolt (smoltification) during the spring. In this process there are changes in behavior and physiology that prepare the smolts for survival in salt water. Elevated water temperatures that interrupt the smoltification process are known to vary by species based primarily on controlled experiments (see reviews by Wedemeyer et. al. 1980). From literature reviews, Zedonis and Newcomb (1997) identified three categories of thermal tolerance for salmonid smolts in the Trinity River. The three categories—optimal, marginal, and unsuitable—were defined by the relative likelihood that smolts would revert to parr or lose their ability to osmoregulate in seawater. Studies examining relationships between water temperature and smoltification for steelhead have observed a reduction in migratory tendencies in response to elevated temperatures (greater than 55.4ºF) (Zaugg 1981). Reductions in physiological changes of smolts at higher temperatures (59ºF) have also been inferred by Kerstetter and Keeler (1976) when they observed a sharp decline in the number of outmigrating wild steelhead smolts captured in traps.

Species Response to Habitat

The primary action in the Restoration Project is increasing the flow of surface water and cold spring water in the stream channel using the Instream Flow Incremental Methodology. The Instream Flow Council (2002) recommends that adaptive management be used to answer critical uncertainties for the instream flow-setting process as described in Castleberry et al. (1996). The three recommended steps in this adaptive management approach were incorporated with the Restoration Project flow-setting methodology as follows.

- Set conservative, resource-protective interim flow standards based on available information. The flow-setting process used by the Greater Battle Creek Watershed Working Group Biological Technical Team (Kier 1999) developed a conservative resource protective minimum flow regime predicted to provide 89 to 95% of usable habitat based on predictive models for flow and temperature. The results of this flow-setting process were more protective than that of the typical FERC regulatory process because of the influence of a substantial contribution of public funds in the negotiation process.
- Establish a credible monitoring program that allows interim standards to serve as experiments. The Restoration Project MOU includes a funded AMP with detailed monitoring and focused studies expected to monitor the effectiveness of the new flow regime, verify model predictions, and assess attainment of habitat objectives.
- Establish an effective procedure that allows revision of the interim flows. If monitoring of the Restoration Project does not substantiate the modeled predictions, the AMP has the flexibility to make changes to the models and implement another flow option predicted to be more effective. Flow increases can be accommodated with the use of both a publicly funded WAF and an AMF. Together these funding sources have an estimated maximum purchasing capability of 13,000 acre-feet per year 3 years after completion of construction (McCollum pers. comm. 2004). This volume is capable of approximately doubling base flows below Inskip and Eagle Canyon Dams).
- The Eight Dam Removal Alternative provides unimpaired flows to the South Fork Battle Creek and partially impaired flows to the North Fork Battle Creek from the watershed above the project area. The habitat-flow relationships associated with the range of summer base flows associated with the Eight Dam Removal Alternative were compared with that of the Five Dam Removal Alternative and the No Action Alternative (FERC license flow requirements). The base flow period was assumed to be the main season limiting production of fish based on the findings of the geomorphic and hydrology analysis.

Passage at Natural Obstacles and Dams

Effectiveness of passage at dams was examined in relation to the contemporary standard for fish ladders summarized by DWR (2000). The no effect level for passage delay for migrating salmon is 3 days during periods of less-than-extreme hydrology (less than the highest flow in a decade) (Katopodis 1992). An additional consideration for ladders is a review of features that minimize delay associated with operation and maintenance, including remote sensing equipment to detect problems and summon maintenance as soon as possible along with good access for equipment. The passage condition and migration delay with dam removal would be what it was before the dam was constructed. Although those conditions are unknown because there are thick sediment deposits behind the dams that obscure the stream bottom, the presence of a buried natural obstacle under the sediment is considered unlikely based on the fact fish ladders were required in the early 1900s. Natural obstacles that could impair migration were surveyed in Battle Creek in relation to minimum flows necessary to pass over the barriers (Jones & Stokes 2003, Kier 1999, and Thomas R. Payne and Associates 1999). The flow-setting method incorporated the flow needs to provide passage at natural obstacles during the migration period.

Results and Discussion

Sediment Transport

Following is a summary from the March 15 presentation. Kondolf and Katzel (1998) found that there did not appear to be any obvious or serious locations of sediment imbalance in the Battle Creek system. This indicates that even with all the dams in place, there does not seem to be a serious impact on sediment transport. This is likely attributable to the small size of the dams and the operation of the sluice gates. In a more detailed analysis, Kondolf and Katzel (1998) estimated the magnitude of a flood event that moves sediment. This hydrologic information was adjusted and applied to examine effects of the three additional dam removals included in the Eight Dam Removal Alternative. In Figure 2, the blue bars indicate the 1.5-year return intervals that tend to make gravel move. The gray blocks are the 0.6 to 0.8 range, and the red blocks represent the diversion quantities. The diversion quantities are small relative to the magnitude of the 1.5-year return floods, and they do not cause the blue area to drop down below the zone where sediment transport starts to occur. With respect to duration, there was agreement among the specialists that the event would have to last for 2 to 3 days for sediment to move. In summary, the Eight Dam Removal Alternative offers little sediment transport benefit over that provided by the Five Dam Removal Alternative. Some scientific uncertainty exists regarding sediment transport relations in the Battle Creek system as recognized and addressed in the Sediment Management Plan that will be part of the AMP.

Hydrology

Figure 3 compares hydrographs simulated for the different cases including the existing FERC conditions. The Five Dam Removal Alternative increases minimum flows over the existing FERC conditions by approximately one order of magnitude (Figure 3 inset) and the Eight Dam Removal Alternative increases it even more. The Eight Dam Removal Alternative does not substantially change the pattern and variability of the hydrograph for a normal year in Battle Creek over that provided by the Five Dam Removal Alternative. The pattern of seasonality in the hydrograph is similar in the two cases. However, the Eight Dam Removal Alternative does increase the magnitude of the flow. The seasonal pattern of the hydrograph is maintained because there is no major storage reservoir in the Battle Creek hydro system to impair runoff from storm and snow melt events, and the hydro diversions are small relative to wet season events.

The floodflow portion of the hydrograph is important for geomorphic and sediment transport activities in the stream. As discussed earlier, the additional magnitude of the Eight Dam Removal Alternative offers little sediment transport benefit over that provided by the Five Dam Removal Alternative. The receding limb of the hydrograph comes at a time when juvenile salmonid emigration occurs for most of the species. The pattern shown on the receding limb for the Five Dam Removal Alternative and for the Eight Dam Removal Alternative is the same with respect to slope and variable inflections representing storm or runoff events. This indicates that the juvenile fish are receiving the similar environmental cues for emigration with respect to flow.

Temperature Regime

The Eight Dam Removal Alternative and the Five Dam Removal Alternative both significantly decrease the temperatures in June to September compared to what is provided under the existing minimum required flows of 3 and 5 cfs in the FERC license (Attachment B—SNTEMP model output). The temperature regimes are identical in one half of the project area in both the Eight Dam Removal Alternative and Five Dam Removal Alternative during the June through September period. Figures 4 through 11 show identical longitudinal profiles in the North Battle Creek Feeder and South Diversion reaches under the Eight Dam Removal Alternative and Five Dam Removal Alternative. However, it should be noted that the displays are not explicitly clear because the temperature profile lines are on top of each other (i.e. identical) and do not extend above the uppermost dams in the project area. In these 21 miles of stream above both Eagle Canyon and Inskip Diversion Dams, dry season water flows are the same in both cases because under the Five Dam Removal Alternative there is no dry season diversion at North Battle Feeder Diversion Dam, South Diversion Dam is removed and hydrology above these two uppermost dams is identical in either case. These higher elevation reaches constitute the coldest reaches in their respective forks. Below Inskip and Eagle Canyon Diversion Dams, the Eight

Dam Removal Alternative extends cooler temperatures downstream to lower elevations than does the Five Dam Removal Alternative with localized exceptions of some coldwater refugia areas associated with inputs from spring or spring-fed tributaries.

Coldwater refugia are biologically very important, and the Five Dam Removal Alternative performs better than the Eight Dam Removal Alternative at adaptively managing the formation the coldwater refugia with the coldest possible temperatures while meeting habitat needs. An example of a quantifiable difference is at Eagle Canyon Dam where significant cold spring flows (12 cfs) enter the stream below the diversion at a temperature 3 to 5º colder than surface water above the dam. Removal of the dam under the Eight Dam Removal Alternative adds more of the warmer surface water that dilutes out the cooling effect of the springs and diminishes the amount of habitat available at the minimum possible temperature (Table 2). Additional coldwater refugia are expected to form at other coldwater inputs as indicated on the longitudinal temperature profiles by sharp temperature decreases at specific points along the profile. The formation of coldwater refugia will depend on concentrating coldwater inputs in quiescent areas of the stream; such as stratification in pools. There will be some relationship between flow and formation of these cold microhabitats as a result of the effects flows can have on mixing and/or dilution. Because the Eight Dam Removal Alternative has much higher flows, it has the potential to disrupt coldwater refugia that would otherwise form. Some scientific uncertainty exists with the formation and distribution of coldwater refugia throughout the Battle Creek system as recognized and addressed in the coldwater refugia study that will be part of the Adaptive Management Program. In addition, the AMP in the Five Dam Removal Alternative includes a WAF that can increase flows on an as-needed basis at Inskip and/or Eagle Canyon Dams to levels approximately double that prescribed for the base flow period.

Species Response to Temperature

Figures 4 through 11 display June, August, and September longitudinal temperature regimes predicted for the Eight Dam Removal Alternative and Five Dam Removal Alternative as compared to different temperature tolerance zones for temperature-sensitive life stages at vulnerable times. The relative benefits provided by the different temperature regimes are indicated by changing the temperature from a lesser to a better range of temperature tolerance for the temperature-sensitive life stages over a significant portion of the project area. Both the Five Dam Removal Alternative and the Eight Dam Removal Alternative provide temperature regimes that are significantly improved over that provided by the existing FERC license conditions of 3 and 5 cfs, in which the water heats up rapidly over distance downstream (Attachment B). Between the Five Dam Removal Alternative and Eight Dam Removal Alternative, there is no difference in the temperature tolerance in the uppermost half of the project area located above Eagle Canyon Dam on the North Fork Battle Creek and Inskip Dam on the

South Fork because the temperature regimes are generally the same. Within the remaining half of the project area, the mainstem constitutes approximately half (i.e., one quarter of the project area). Under either the Eight Dam Removal Alternative or the Five Dam Removal Alternative in the warm months there is not a significant improvement that would make this reach suitable for temperature-sensitive life stages (embryos, prespawning adults, and smolts) during critical base flow periods. However, the lowest elevation section of the mainstem is generally cooler under the Eight Dam Removal Alternative. There are also potential coldwater refugia in portions of the mainstem that will need to be considered.

Comparing temperature tolerance for the two flow cases (Eight Dam Removal Alternative and Five Dam Removal Alternative) focuses on the two stream segments between Inskip Dam and the mainstem confluence and Eagle Canyon Dam and the mainstem confluence making up approximately one quarter of the project area. In this area, under normal conditions, incubating embryos (Figure 4 and Figure 5) are expected to find some stream segments where more than half of the embryos survive (blue shaded zones) and estimated survival rates within those stream segments are not significantly different in the two cases. The temperature zone preferred for holding prespawning adult spring-run Chinook salmon (Figure 6) does not show any significant difference in the two cases. The winter-run juveniles present in September (Figure 7) are expected to find normal year temperatures in the preferred zone in the Eagle Canyon reach where there is no significant difference in the two cases. The last of the spring-run Chinook salmon smolt outmigrants present in June (Figure 8) are expected to find normal year temperatures in the optimum and marginal zones below Eagle Canyon and Inskip Dams, respectively; and there is no significant difference in the two cases. However, there is an additional mile of the optimum zone below Inskip under the Eight Dam Removal Alternative. The last of the steelhead smolt outmigrants that are present in June (Figure 9) are not expected to find normal year conditions better than marginal, and there is no significant difference in the type of exposure between the two cases.

Temperatures in June under extreme drought and extreme warm weather, a rare and biologically very harmful combination, indicate that the first mile below Eagle Canyon Dam is the most important area for forming coldwater refugia in the stream segments between Eagle Canyon and Inskip Dams and the confluence of the forks.

Species Response to Habitat

Under the Five Dam Removal Alternative, the focus species within each reach were prioritized by the Greater Battle Creek Watershed Working Group Biological Technical Team following Endangered Species Act criteria clarified by NOAA Fisheries as described in a report to the Greater Battle Creek Watershed Working Group August 26, 1998 (Kier 1998). Provided that suitable

habitat existed in a given reach, the result of the species prioritization in descending order of importance was: 1) winter-run Chinook salmon, 2) spring-run Chinook salmon, 3) steelhead trout, and 4) fall- and late fall–run Chinook salmon. The suitability of a particular reach for a given species was determined considering restorable temperature regimes, coldwater accretions from springs, physical habitat characteristics, species life history, and length of stream reach, stream gradient, and presence of natural obstacles to migration. Appropriate weighted usable area curves reported in the Instream Flow Incremental Methodology study were then selected with the help of a limiting life stage model. Final flow determinations were typically a flow providing 95% of the maximum weighted usable area for a focus species life stage (range of 90 to 95% of habitat predicted to be usable). Other considerations, include adequate flow for adult salmon migration at natural obstacles to migration, sediment transport, balancing overlapping life stages, and preventing redd dewatering. Particular focus was placed on the base flow period of the hydrograph because the dams did not significantly affect floodflows and the variability of the pattern in the seasonal hydrograph. Finally, flow values were examined for the temperature regime they provide to the stream using the most updated version of the SNTEMP model. The CALFED Review Panel for the Restoration Project found this flow-setting procedure to be relevant and appropriate in the context of the AMP (CALFED 2003).

The Biological Technical Team recognized the inherent uncertainty in the use of IFIM, SNTEMP, and limiting life stage models, as well as in estimations of migration flows or physical changes at natural barriers (Kier 1998). Because of the uncertainty in predicting usable physical habitat and temperature, the AMP includes a WAF that has a maximum purchasing power of 13,000 acre-feet per year (estimated from future power prices developed for the Eight Dam Removal Alternative). The AMP also recognizes the uncertainties with respect to carrying capacity that the Five Dam Removal Alternative provides to the target species. At this time, exceedingly small populations of target species are supported by the limited amount of habitat. Existing conditions suggest the Five Dam Removal Alternative provides more space than needed for the small populations expected over the coming decade(s).

The amounts of usable habitat predicted to be made available under the Eight Dam Removal Alternative and Five Dam Removal Alternative are compared for the areas where the flow is different in Figures 12 through 14. The amount of usable habitat predicted under the Eight Dam Removal Alternative for the priority species and life stages is not significantly different from that under the Five Dam Removal Alternative, particularly given the inherent uncertainty of IFIM. An additional consideration is whether there is sufficient purchasing capacity in the WAF to approximately double base flows if they are available, if future scientific studies indicate a need for additional water.

Passage at Natural Obstacles and Dams

The Five Dam Removal Alternative builds and maintains ladders on Eagle Canyon, Inskip, and North Battle Creek Feeder Diversion Dams, which are significantly larger than existing facilities (exit/attraction flows on new ladders are 30 to 50 times existing levels). Figure 15is a schematic diagram of the fish ladder at Inskip Diversion Dam, showing its size relative to the channel. In addition, this alternative removes five dams, leaving passage conditions as they were before the dams were constructed (assuming no natural obstacles lie buried under the sediment deposits behind the dam). Adult passage delays for salmon are not considered significant unless they exceed 3 days (Katopodis1992). Delay problems can be related to shutdowns for maintenance and substandard amounts of attraction flow at the ladder exit during extreme high-flow events. The designs for the three new ladders meet all the present-day standards to avoid delay problems (DWR 2000). Current accepted standard for ladder design during extreme high-flow events is to allow a delay exceeding 3 days to occur one time every 10 years at flows when fish can move in the channel (Katopodis 1992, DWR 2000). However, such a long recurrence interval is considered to reduce the impact of this delay to less than significant because it is encountered by such a small portion of the total population over a decade. Maintenance requirements for ladders are expected to cause less than a 3-day delay for migrating fish at any one time under the Five Dam Removal Alternative. Maintenance-caused delays should be less than in the past because of design improvements in the proposed ladders, including enlarged size, installation of trash racks and floodwalls, improved accessibility for maintenance equipment, and installation of remote sensing equipment to detect problems and summon maintenance efforts as needed. The three new fish ladders are not expected to cause a significant impact on the migration of salmon and steelhead.

The Five Dam Removal Alternative also builds and maintains screens at the same three dams where ladders are installed. All screens are designed to meet current criteria (DWR 2000). Although fish ladders and fish screens have been operated in California waters for more than 100 years (DFG 1952) and many improvements have been achieved in design and operation, some degree of uncertainty is still recognized. Consequently, the AMP is funded with up to $6 million for necessary modifications to facilities. Under the MOU, the owner of the hydroelectric project is responsible for maintenance and replacement of facilities. The CALFED Technical Review Panel for the Restoration Project found the designs to meet all current standards and criteria for fish passage, and some refinements were made to designs as a result of this review.

The main difference in the Eight Dam Removal Alternative is that there would be fewer maintenance issues because there are no screens or ladders. The passage condition and migration delay with dam removal would be what it was before the dams were constructed, although those conditions are unknown because there are thick sediment deposits behind the dams that obscure the stream bottom. The

presence of a natural obstacle buried under the sediment is considered unlikely, however, based on the fact fish ladders were required in the early 1900s.

Passage at natural barriers is more uncertain than passage at fish ladders. A wide variety of natural obstacles occur in Battle Creek (Figure 16). There is substantial uncertainty on how these natural barriers may change through time, from natural and project-related changes in flow and channel form. The AMP with the Five Dam Removal Alternative recognizes this uncertainty and provides flexibility through monitoring and flow management to determine and implement appropriate passage conditions at barriers. Adaptive management also may identify options to use certain barriers for separating different runs of Chinook salmon to different habitat areas of Battle Creek and thus maintain genetic integrity of the specific runs.

The Eight Dam Removal Alternative provides more flow at barriers than the Five Dam Removal Alternative; however, increased flows are not necessarily beneficial in all cases to fish passage at natural barriers. High flows may impair passage, especially at obstacles in a narrow box canyon setting. The Five Dam Removal Alternative may provide more flexibility through adaptive management of flows to enhance passage at natural barriers than the Eight Dam Removal Alternative.

Conclusions

Compared to existing conditions under the FERC license, it is clear that both the Five Dam Removal Alternative and Eight Dam Removal Alternative alternatives significantly improve habitat and passage conditions for the target species and meet the needs of those species. It is concluded that there is not a significant difference in the amount of improvement over existing conditions provided by the Eight Dam Removal Alternative compared to that provided by the Five Dam Removal Alternative. Within the 42-mile Restoration Project area, there are approximately 22 miles where the Five Dam Removal Alternative and the Eight Dam Removal Alternative provide identical conditions with respect to flow and temperature during the important period of June through September. The only differences that could be found during this period were located below Inskip and Eagle Canyon Diversion Dams to the downstream terminus of the project area. In summary the habitat and passage conditions predicted for the Eight Dam Removal Alternative did not represent a significant improvement over those predicted for the Five Dam Removal Alternative in examining the following factors:

1) Geomorphology: Removal of North Battle Creek Feeder, Eagle Canyon, and Inskip Diversion Dams does not provide a substantial improvement in the Battle Creek system's sediment transport characteristics necessary for maintaining spawning areas. The dams are too small to appreciably alter either the magnitude

or duration of a flow event known to affect geomorphic change or serve as sediment sinks.

2) Habitat and Temperature: The Eight Dam Removal Alternative does not substantially increase the predicted minimum amount of habitat usable by the target species for spawning or rearing over that of the Five Dam Removal Alternative. The Five Dam Removal Alternative flows were prescribed using an integrated instream flow process that selected a robust flow regime (90 to 95% of predicted usable habitat) coupled with an AMP to procure more water as needed. The CALFED Review Panel for the Restoration Project found this flow-setting procedure to be relevant and appropriate.

The summer temperature regime predicted to result from the Eight Dam Removal Alternative does not substantially improve the regime for fish in each stream reach. Improvement is indicated by changing the temperature from a lesser to a better range of temperature tolerance for temperature-sensitive life stages. In the summer the valley reaches of Battle Creek are not suitable for the most temperature-sensitive life stages of the target species (embryos and smolts) under either alternative, and in some cases even with unimpaired flow. The temperature regimes of the two alternatives were compared to ranges of temperature tolerance for sensitive life stages of the target species at times when they are present. Evaluated temperature tolerance ranges included incubation, smoltification, juvenile survival, and adult holding. In almost all combinations of life stages and stream reaches, the predicted temperatures of the two alternatives parallel each other in the same temperature tolerance zone. In a limited number of cases within a limited portion of a stream reach (generally 1 mile), the Eight Dam Removal Alternative had a lower temperature regime that attained better temperature criteria (i.e., moving from marginal to optimum). The Five Dam Removal Alternative provides more adaptive management opportunity for creating coldwater refugia below Eagle Canyon Diversion Dam. Because of the uncertainty in predicting usable physical habitat and temperature, there is an AMF that has a maximum purchasing power of 13,000 acre-feet per year (estimated from future power prices developed for the Eight Dam Removal Alternative). An additional consideration at this time is that the amount of physical habitat the Five Dam Removal Alternative provides to the target species is much greater than the space needed for the exceedingly small populations of those species presently supported by the limited amount of habitat under existing conditions.

3) Hydrology: The Eight Dam Removal Alternative does not substantially change the pattern of the hydrograph for a normal year in Battle Creek with respect to the pattern of seasonality in the hydrograph; however, it does increase the magnitude of the flow on that pattern. The seasonal pattern of the hydrograph is maintained because there is no major storage reservoir in the Battle Creek hydro system to impair the runoff produced from storm and snow melt events and the hydro diversions are small relative to wet season events.

4) Passage: The fish passage facilities designed for Eagle Canyon, Inskip, and North Battle Creek Feeder Diversion Dams are not expected to substantially interfere with passage of populations of adult or juvenile fish up or down the stream. The CALFED Technical Review Panel for the Restoration Project found the designs to meet all the current standards and criteria for fish passage. In comparison to Eight Dam Removal Alternative, individual fish may encounter limited instances of passage delay in migration attributable to fish ladder design and operation. Adult passage delays are not considered significant unless they exceed 3 days. Delays because of maintenance are all expected to be less than 3 days. Delays because of design limitations on ladder sizing for extreme high-flow events will be expected to occur at the rate of one delay exceeding 3 days every 10 years; however, that is not expected to be a significant delay because it represents a small portion of the population encountering a problem each decade. Compared with the science of fish ladders, passage at natural barriers is more like an art. There is a lot of uncertainty associated with these barriers that will require the attention of the AMP. The Eight Dam Removal Alternative provides more flow at barriers than the Five Dam Removal Alternative; however, increased flows are not necessarily beneficial in all cases to fish passage at natural barriers. A great deal of uncertainty is associated with this issue, so the same level of adaptive management is expected for both alternatives.

5) Species Recovery Considerations: The Five Dam Removal Alternative will amend the FERC License two decades prior to its expiration in year 2026; the schedule for an amendment under the Eight Dam Removal Alternative is unknown because of uncertainties in reaching a set of complex financial legal and institutional agreements between the agencies and the Licensee. Adverse biological consequences result from missed opportunities to provide listed species with conditions such as drought-resistant refugia that would lead to earlier recovery in areas like Battle Creek.

References

Printed References

Bisson, P. A., and G. E. Davis. 1976. Production of juvenile Chinook salmon *Oncorhynchus tshawytscha*, in a heated model stream. *Fish. Bull*. 74:763–774.

Brett, J. R. 1952. Temperature tolerance in young Pacific salmon, genus *Oncorhynchus*. *J. Fish Res. Bd. Canada* 9:265–325.

California Bay-Delta Authority. 2004. *Final report of the Battle Creek Technical Review Panel.* September. Sacramento, CA.

California Department of Water Resources. 1988. *Water temperature effects on Chinook salmon (*Oncorhynchus tshawytscha*) with an emphasis on the Sacramento River—a literature review.* California Department of Water Resources publication Northern District. 43 pp. Red Bluff, CA.

———. 2000. Battle Creek Salmon and Steelhead Fish Ladder and Screen Features. Preliminary Engineering Concepts Technical Report. May. Red Bluff, CA.

California Department of Fish and Game. 1952. Stopping them; the development of fish screens in California. *California Fish and Game Quarterly* Volume 38, No 1. 61 pp. Sacramento, CA.

Castleberry, D. T., J. J. Cheh, Jr., D. C. Erman, D. Hankin, and others. 1996. Uncertainty and instream flow standard. *Fisheries* (8):20–21.

Greimann, B. 2001. Hydrology of North and South Fork Battle Creek, Battle Creek Restoration Project. April. Denver, CO.

Groot, M. C., and L. Margolis (editors). *Pacific salmon life histories*. UBC Press: Vancouver, British Columbia.

Instream Flow Council. 2002. *Instream flows for riverine resource stewardship*. 411 pages. Available at: www.instreamflowcouncil.org

Jones & Stokes. 2003. *Battle Creek Salmon and Steelhead Restoration Project environmental impact statement/environmental impact report*. Draft. Prepared for U.S. Department of Interior, Bureau of Reclamation, and State Water Resources Control Board. July. Sacramento, CA.

Katopodis, C. 1992. *Introduction to fishway design*. Freshwater Institute Central Arctic Region, Department of Fisheries and Oceans, Winnipeg Manitoba.

Kerstetter, T. H., and M. Keeler. 1976. *Smolting in steelhead trout* (Salmo gairdneri): *a comparative study of populations in two hatcheries and the Trinity River, northern California using gill Na, K, ATPase assays*. Humboldt State University, Sea Grant Program. 35 pp. Arcata, CA.

Kier W. 1999. Battle Creek Salmon and Steelhead Restoration Plan. Prepared for the Greater Battle Creek Watershed Working Group. January. San Francisco, CA.

Kier. W. 1998. Presentation to the Greater Battle Creek Watershed Working Group. August. Biologically optimum instream flow releases. 10 pp. San Francisco, CA.

Kondolf, M., and B. Katzel. 1998. Spawning gravel resources of Battle Creek, Shasta and Tehama Counties. 39 pp with Appendices. Berkeley, CA.

Myrick, C. A., and J. J. Cech. 2001. *Temperature effects on Chinook salmon and steelhead: a review focusing on California's Central Valley populations*. Available at: <http://www.cwemf.org/Pubs/Tempreview.pdf>.

Pacific Gas and Electric Company. 2001. Stream temperature model for the Battle Creek Salmon and Steelhead Restoration Project. January 12. San Ramon, CA.

Raleigh, R. F., T. Hickman, R. C. Solomon, and P. C. Nelson. 1984. Habitat suitability information: rainbow trout. U.S. Fish and Wildlife Service. FWS/OBS-82/10.

Thomas R. Payne and Associates. 1999. Battle Creek Fisheries Studies; Task 4: surveys of barriers to the upstream migration of anadromous salmonids. Prepared for California Department of Fish and Game.

U.S. Department of Interior, Bureau of Reclamation. 1991. *Planning report/final environmental statement Shasta outflow temperature control Shasta County, California*, Final Statement No: FES91 temperature mortality relationship table VI-9 Page VI-39.

U.S. Fish and Wildlife Service. 1990. *Fish and Wildlife Coordination Act report: An analysis of fish and wildlife impacts of Shasta Dam removal water temperature control alternatives*. December. 93 p.

———. 2002. Coleman and Livingston Stone National Fish Hatchery management alternatives analysis (attachment three). Red Bluff, CA. July 15.

Wedemeyer, G. A., R. L. Saunders, and W. C. Clarke. 1980. Environmental factors affecting smoltification and early marine survival of anadromous salmonids. *Mar Fish Rev*. 42 (6):1–14).

Zaugg, W. S. 1981. Advanced photoperiod and water temperature effects on Na+ - K + adenosine triphosphatase activity and migration of juvenile steelhead (*Salmo gairdneri*). *Canadian Journal of Fisheries and Aquatic Sciences* 38:758–764.

Zedonis, P. A., and T. J. Newcomb. 1997. *Flow and temperatures for protection of spring salmon and steelhead smolts in the Trinity River, California*. U. S. Fish and Wildlife Service, Arcata CA. 20 pp.

Personal Communications

McCollum. K. Water Resources Engineer. Navigant Consulting. 2004. Personal communication regarding Water Acquisition Fund water purchasing capacity.

Brown, Matt. Fisheries Biologist. U.S. Fish and Wildlife Service, Red Bluff Fisheries Assistance Office. 2004. Personal communications regarding juvenile outmigrant monitoring project for Battle Creek since the 2001 published data. (Unpublished data since the 2001 report show smolt timing is consistent with that indicated in previously published data for spring-run and steelhead smolts)

Life Stages	Species	Month											
		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	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	■	■	■	■								■
Juvenile Residence	Winter Chinook	■	■	■				■	■	■	■	■	■
	Spring Chinook	■	■	■	■	■					■	■	■
	Fall Chinook	■	■	■	■	■	■						■
	Late-Fall Chinook				■	■	■	■	■	■	■	■	■
	Steelhead	■	■	■	■	■	■	■	■	■	■	■	■

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

Source: Schafter (1980) and Vogel and Marine (1991)

03035.03 007 (10/04)

Jones & Stokes

Table 1
Seasonal Occurrence of Selected Life Stages of Anadromous Salmonids in the Upper Sacramento River, California

Comparison of a Range of Summer Temperatures in North Fork Battle Creek downstream of Eagle Canyon Diversion Dam Site With and Without Removal Under Identical Inflow Above the Site and Spring Flow Below the Site[1]

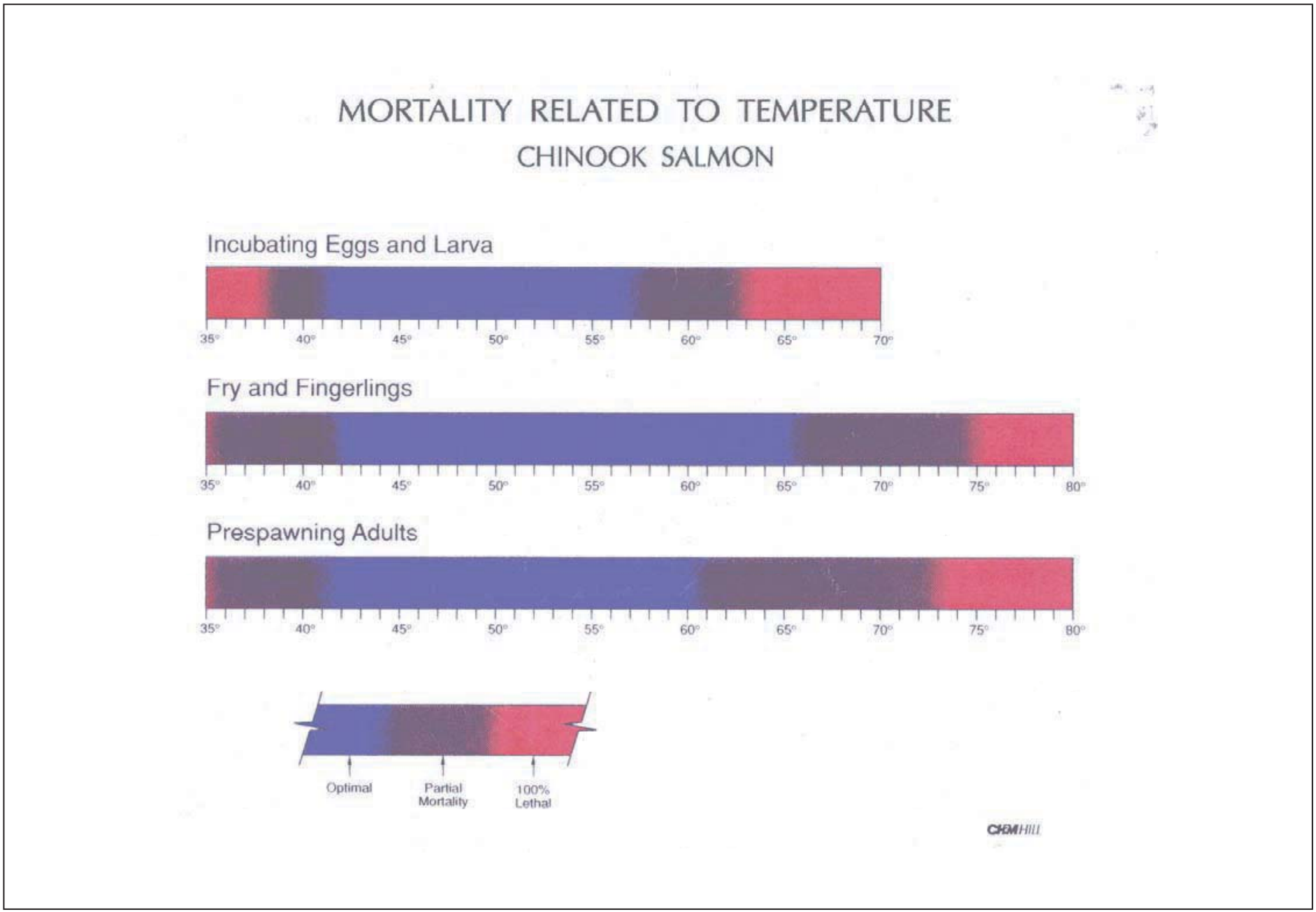
Predicted Temperatures

Above Eagle Canyon Diversion Dam[2] 93 cfs	With Eagle Canyon Diversion Dam diverting inflow and releasing 23 cfs to mix with 12 cfs spring flow	Removal of Eagle Canyon Diversion Dam with all inflow (93 cfs) mixing with spring flow
56°F	54.6°F	55.5°F
57°F	55.3°F	56.4°F
58°F	55.9°F	57.3°F
59°F	56.6°F	58.2°F

[1]Derived using mass balance equation.
[2]PG&E 2001 June

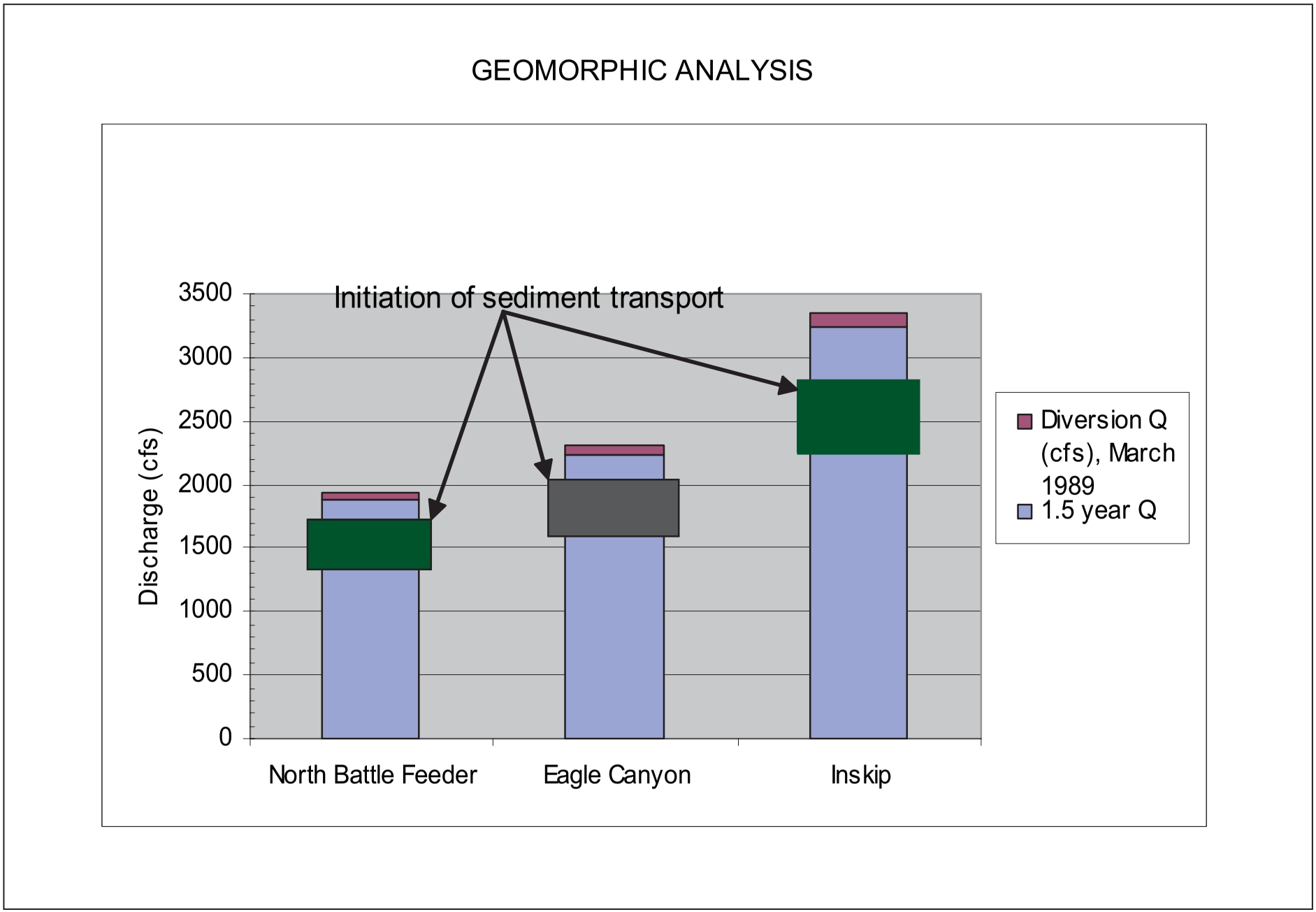
03035.03 007 (09/04)

Table 2
Cold Water Refugia in North Fork Battle Creek Downstream of Eagle Canyon Diversion Dam Site



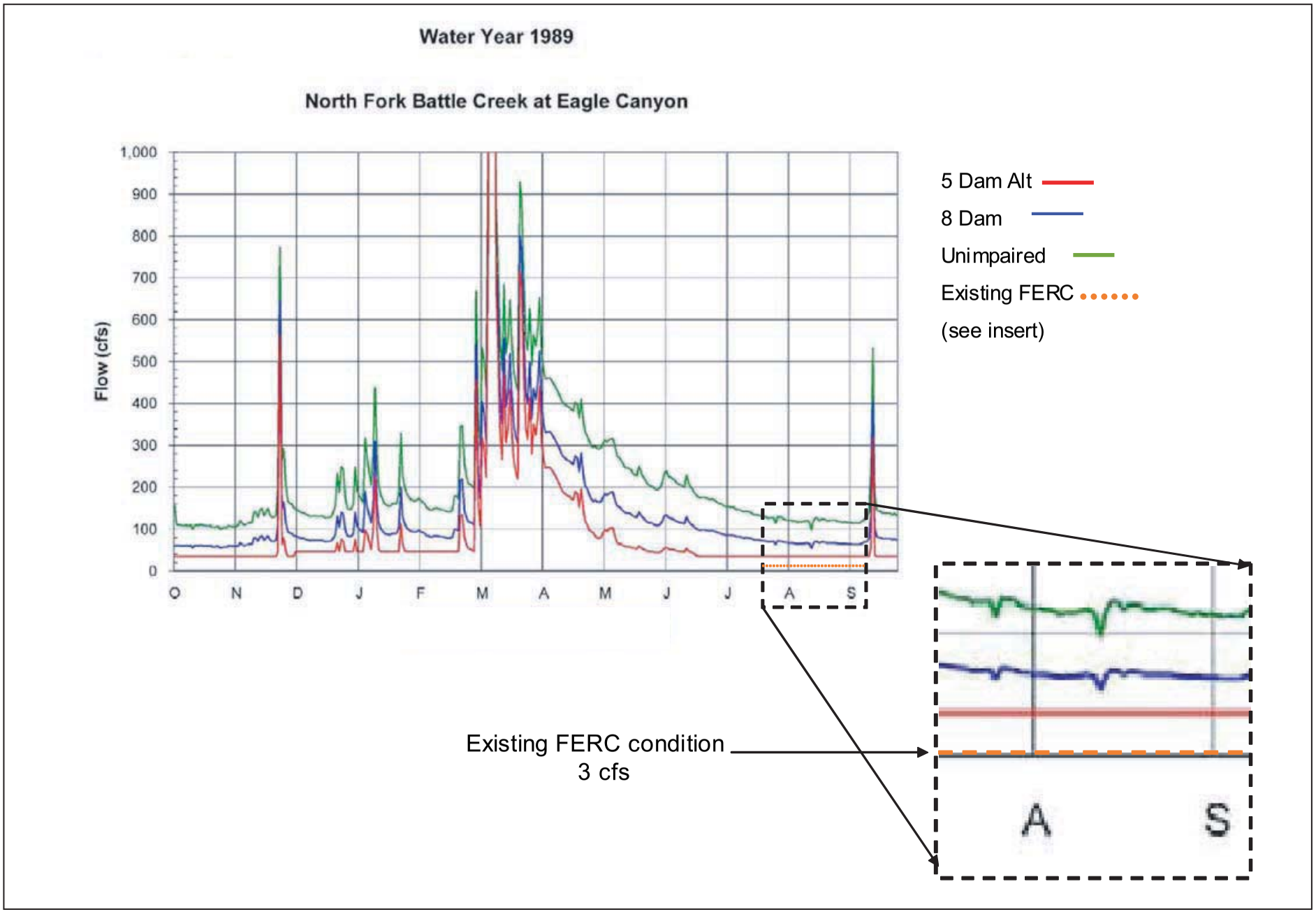
03035.03 007 (09/04)

Figure 1
Mortality Related to Temperature - Chinook Salmon



03035.03 007 (09/04)

Figure 2
Addition of Diversion Magnitudes to the 1.5 Year Return Interval Flow



03035.03 007 (09/04)

Figure 3
Flow in North Fork Battle Creek at Eagle Canyon Diversion Dam (1989)

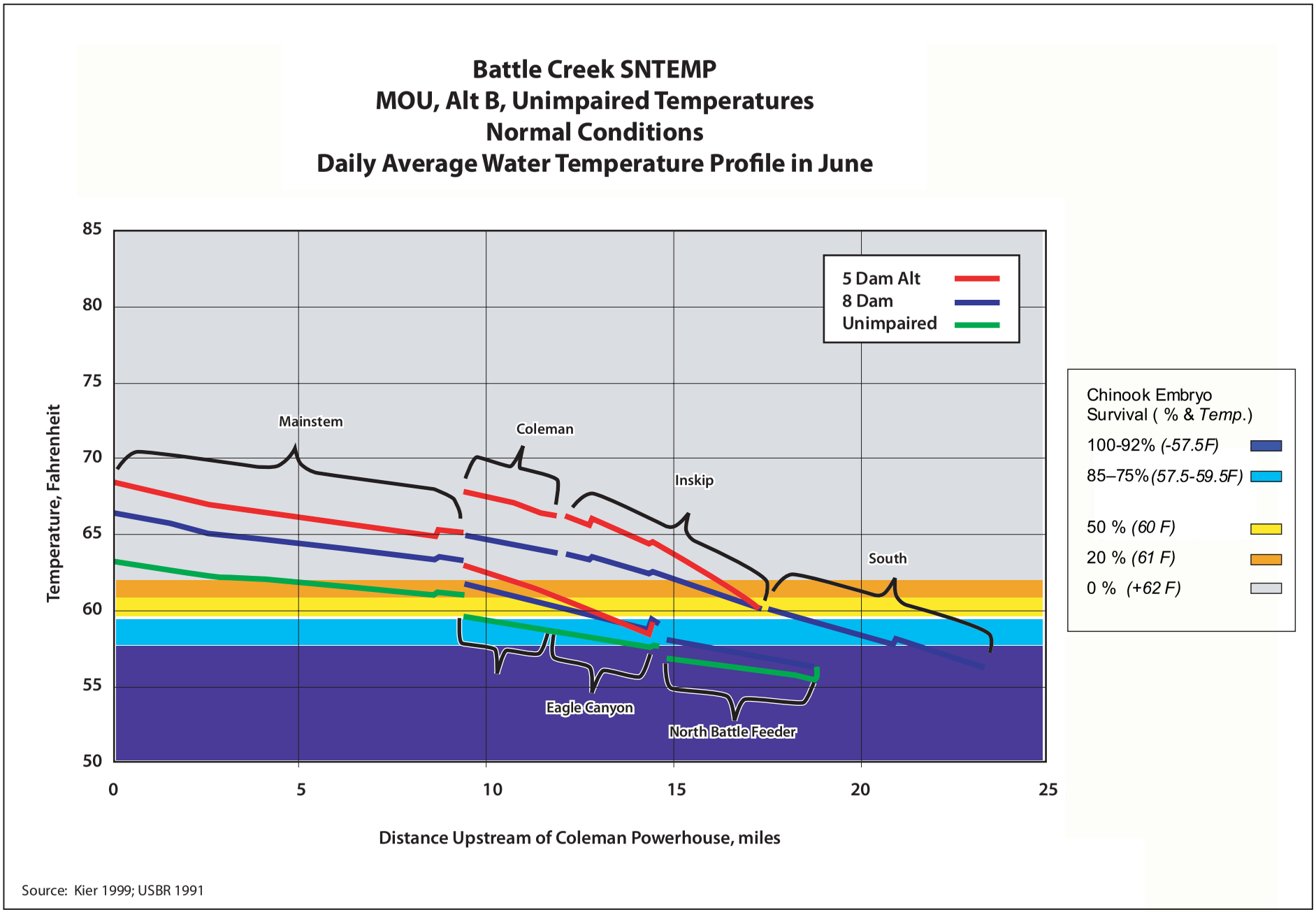
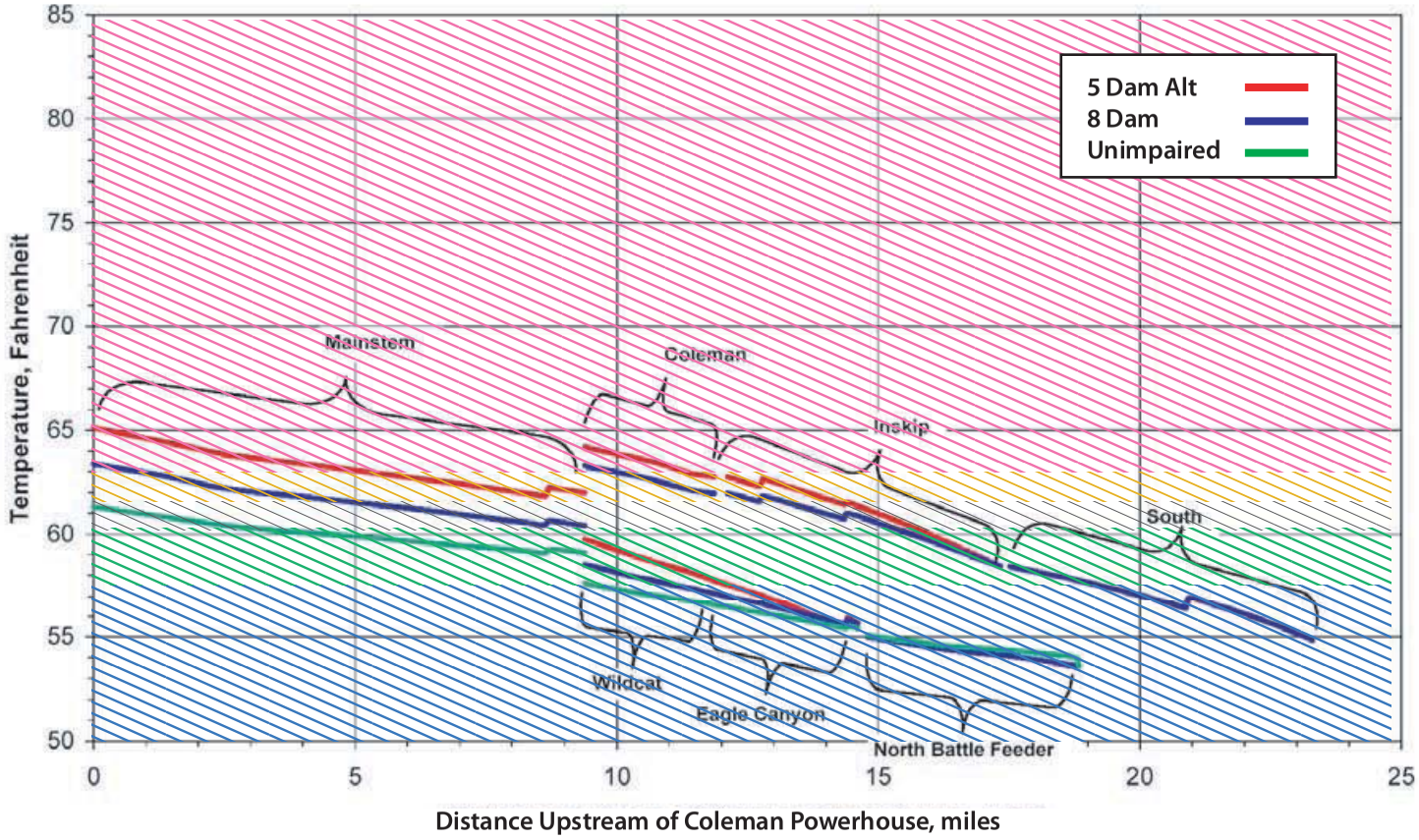


Figure 4
Chinook Embryo Survival
Normal Conditions (June)

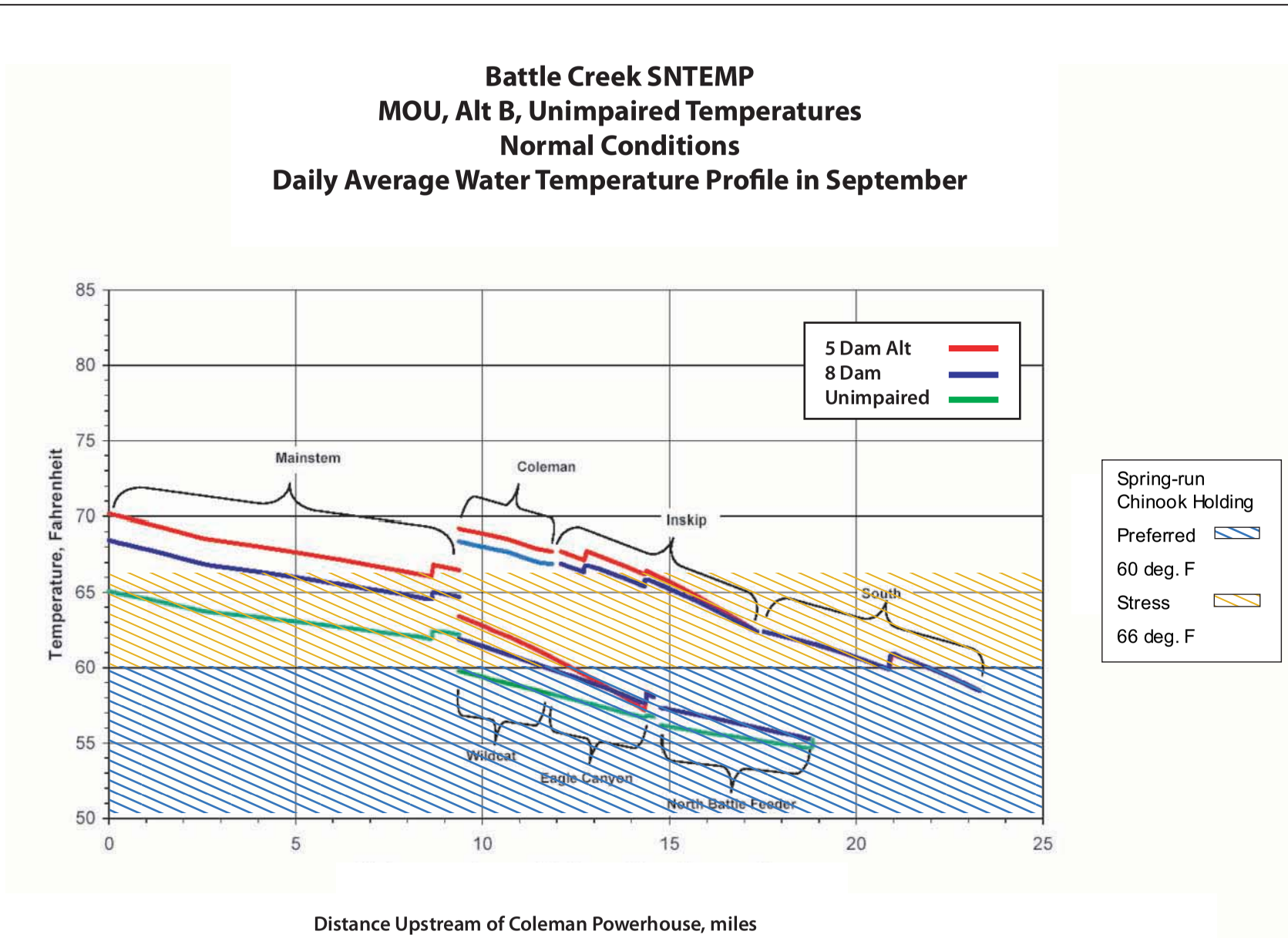
Battle Creek SNTEMP
MOU, Alt B, Unimpaired Temperatures
Normal Conditions
Daily Average Water Temperature Profile in September



Source: Kier 1999; USBR 1991

03035.03 007 (09/04)

Figure 5
Chinook Embryo Survival
Normal Conditions (September)



Source: Kier 1999; USFS 1999

03035.03 007 (09/04)

Figure 6
Adult Chinook Holding Temperature
Normal Conditions (September)

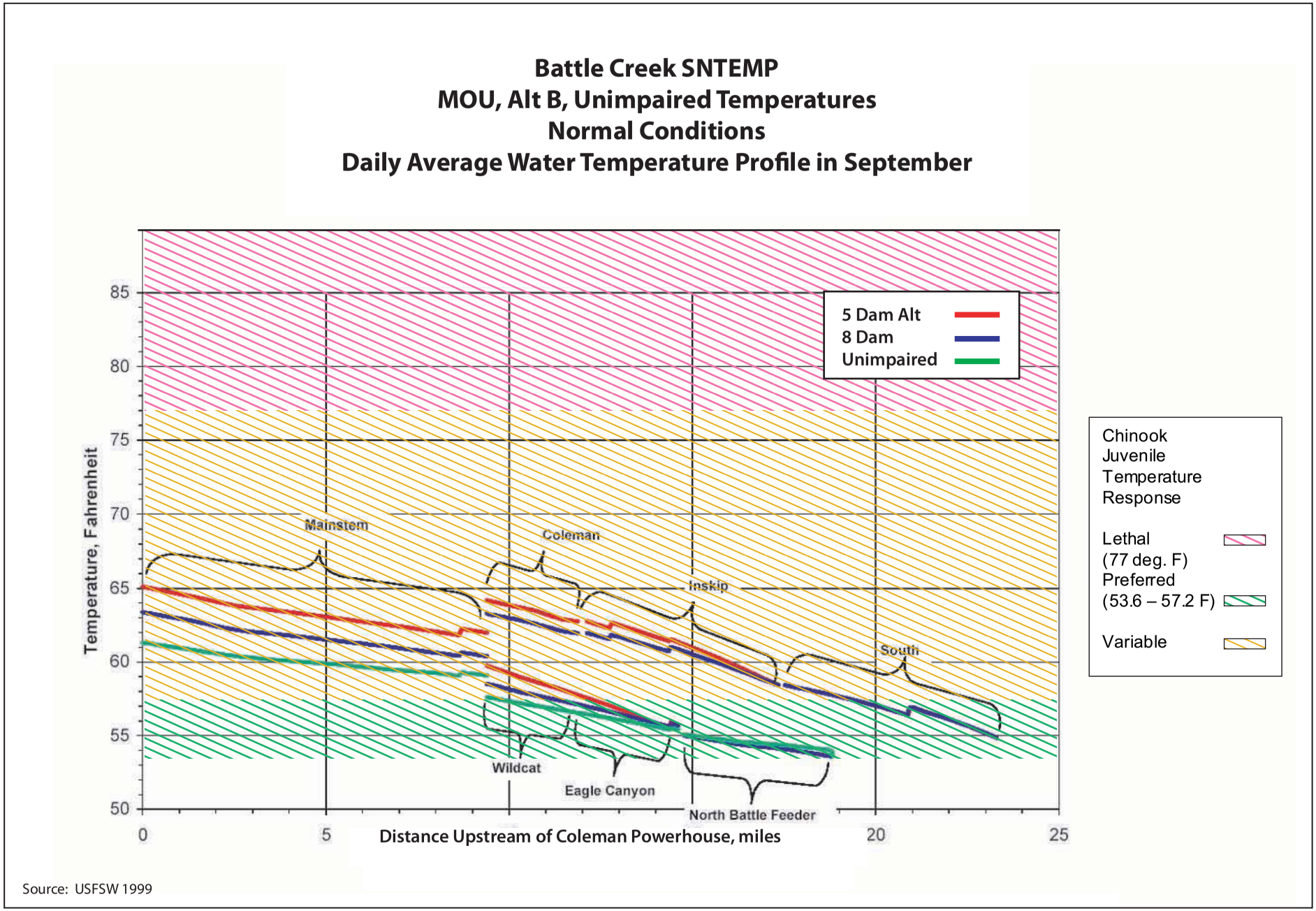


Figure 7
Juvenille Chinook Temperature Response
Normal Conditions (September)

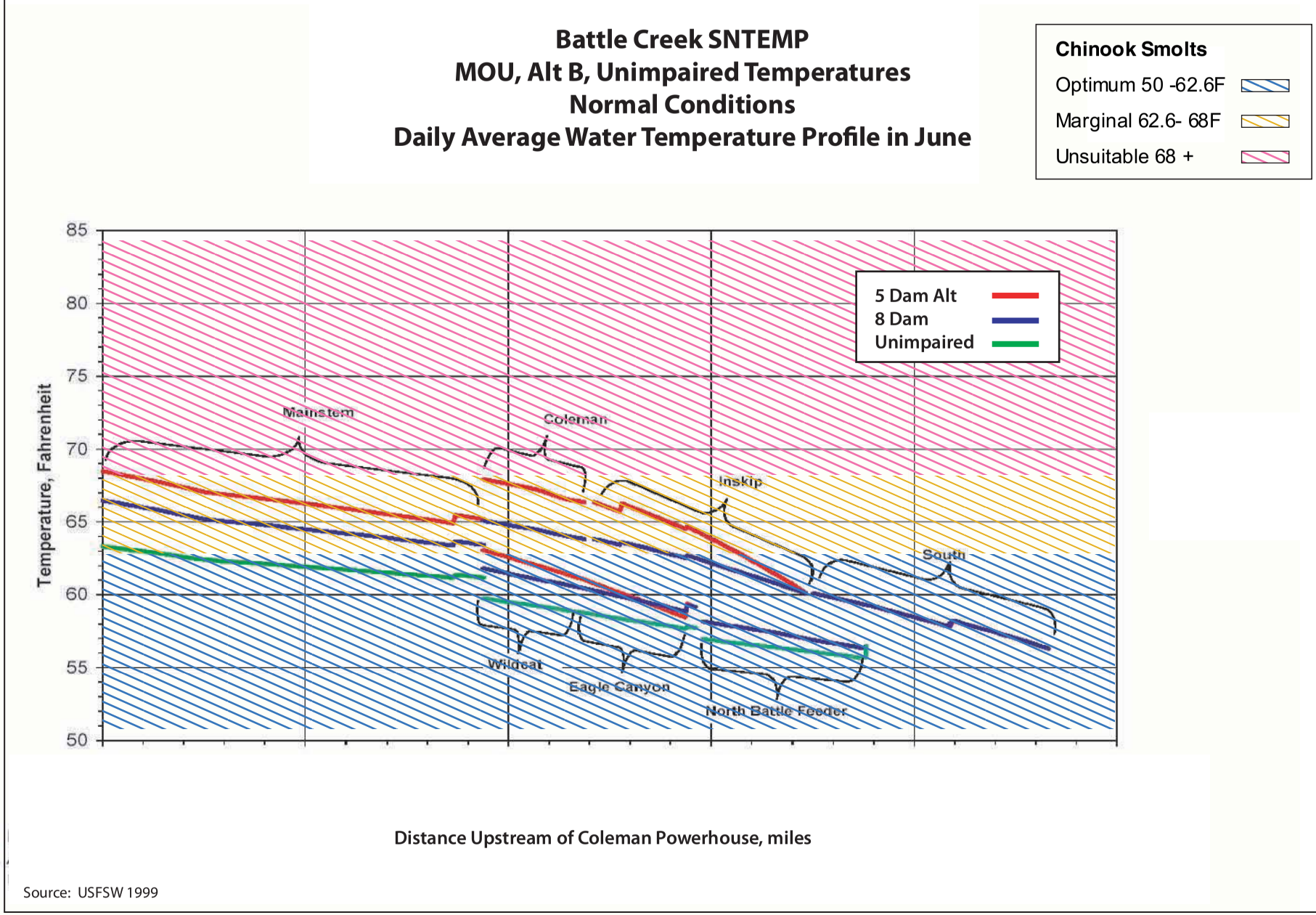
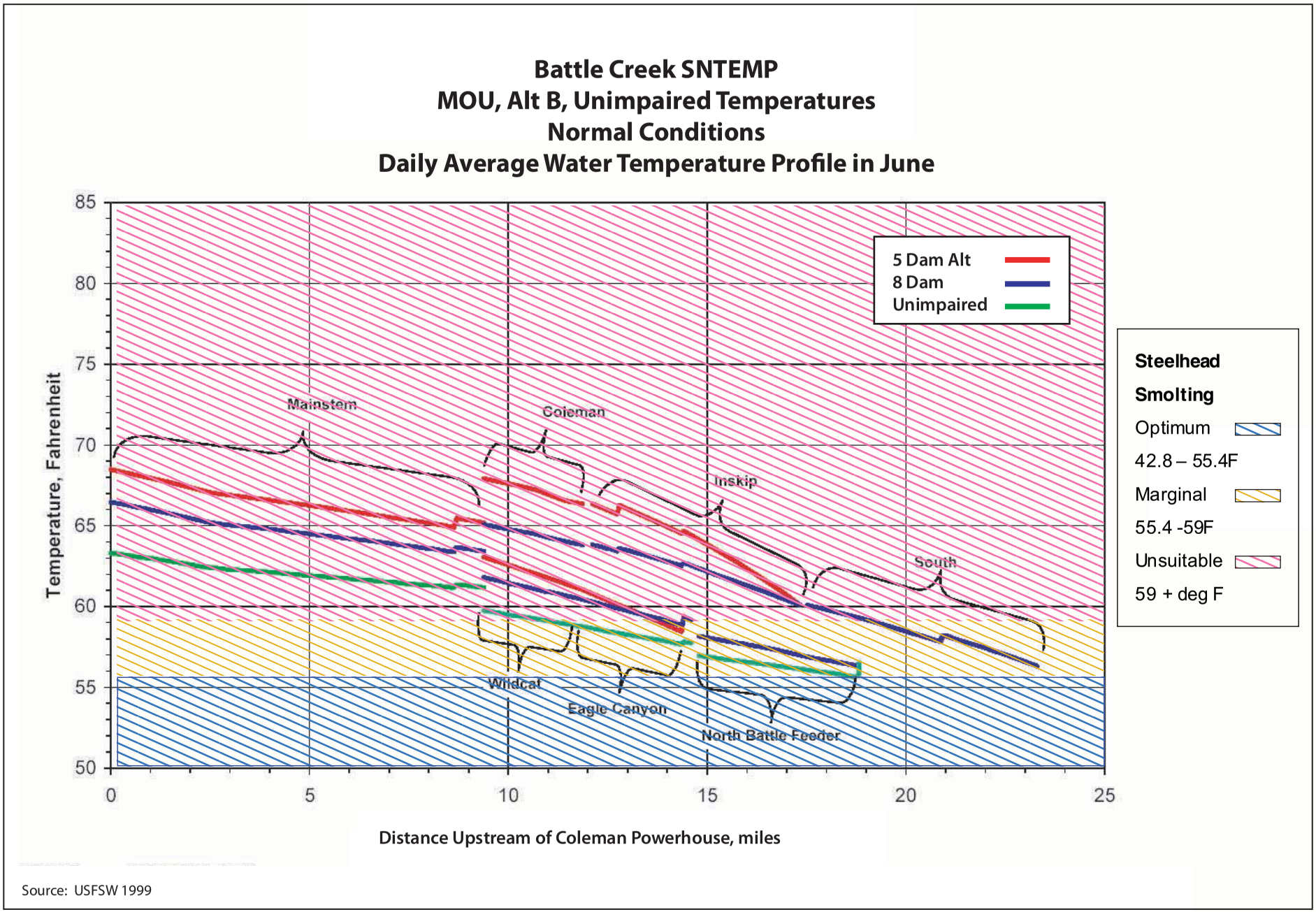


Figure 8
Chinook Smolt Survival
Normal Conditions (June)

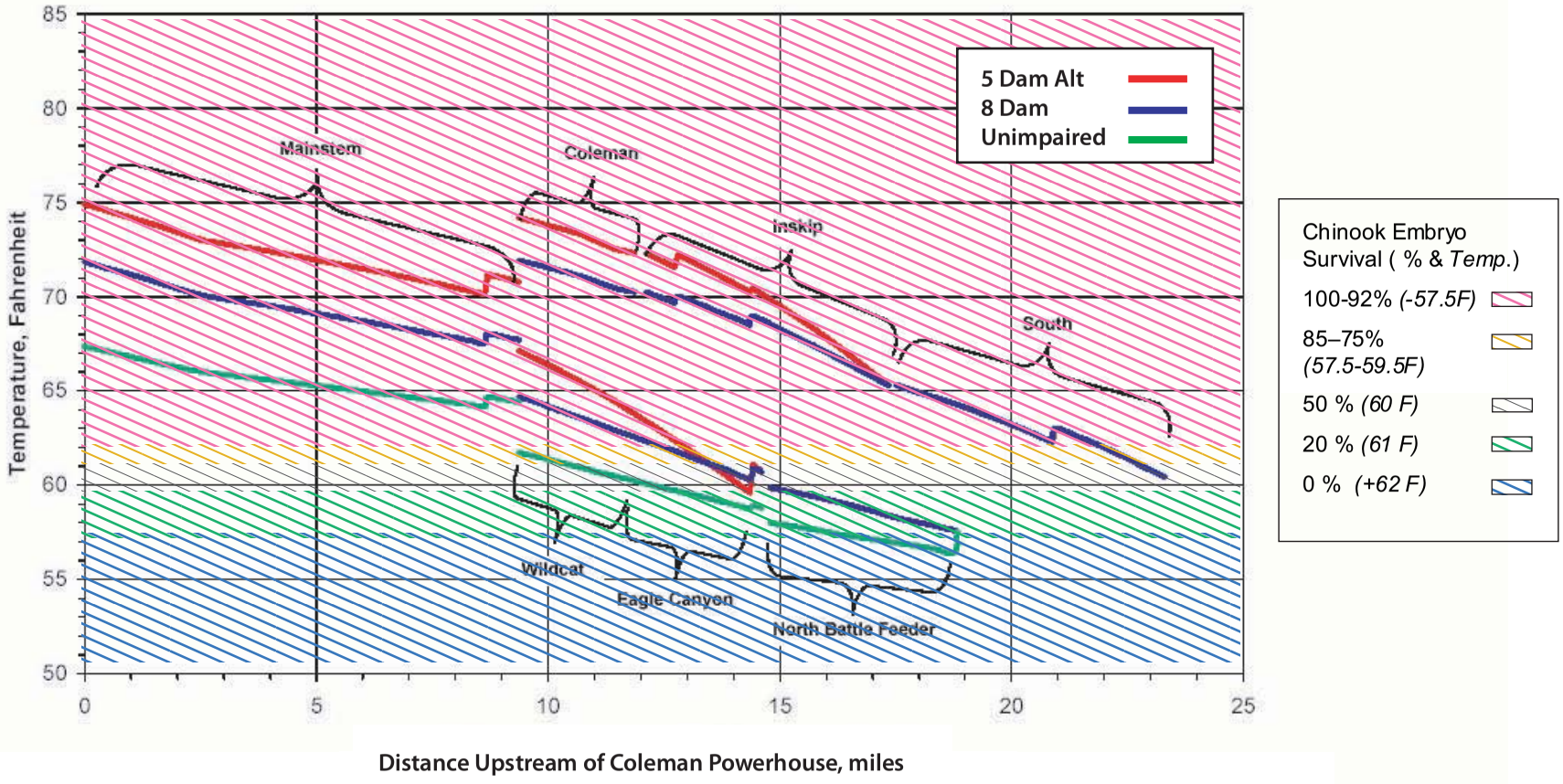


Source: USFSW 1999

03035.03 007 (09/04)

Figure 9
Steelhead Smolt Survival
Normal Conditions (June)

Battle Creek SNTEMP
MOU, Alt B, Unimpaired Temperatures
Normal Conditions
Daily Average Water Temperature Profile in June



Source: Kier 1999; USBR 1991

03035.03 007 (09/04)

Figure 10
Chinook Embryo Survival
Normal Conditions (June)

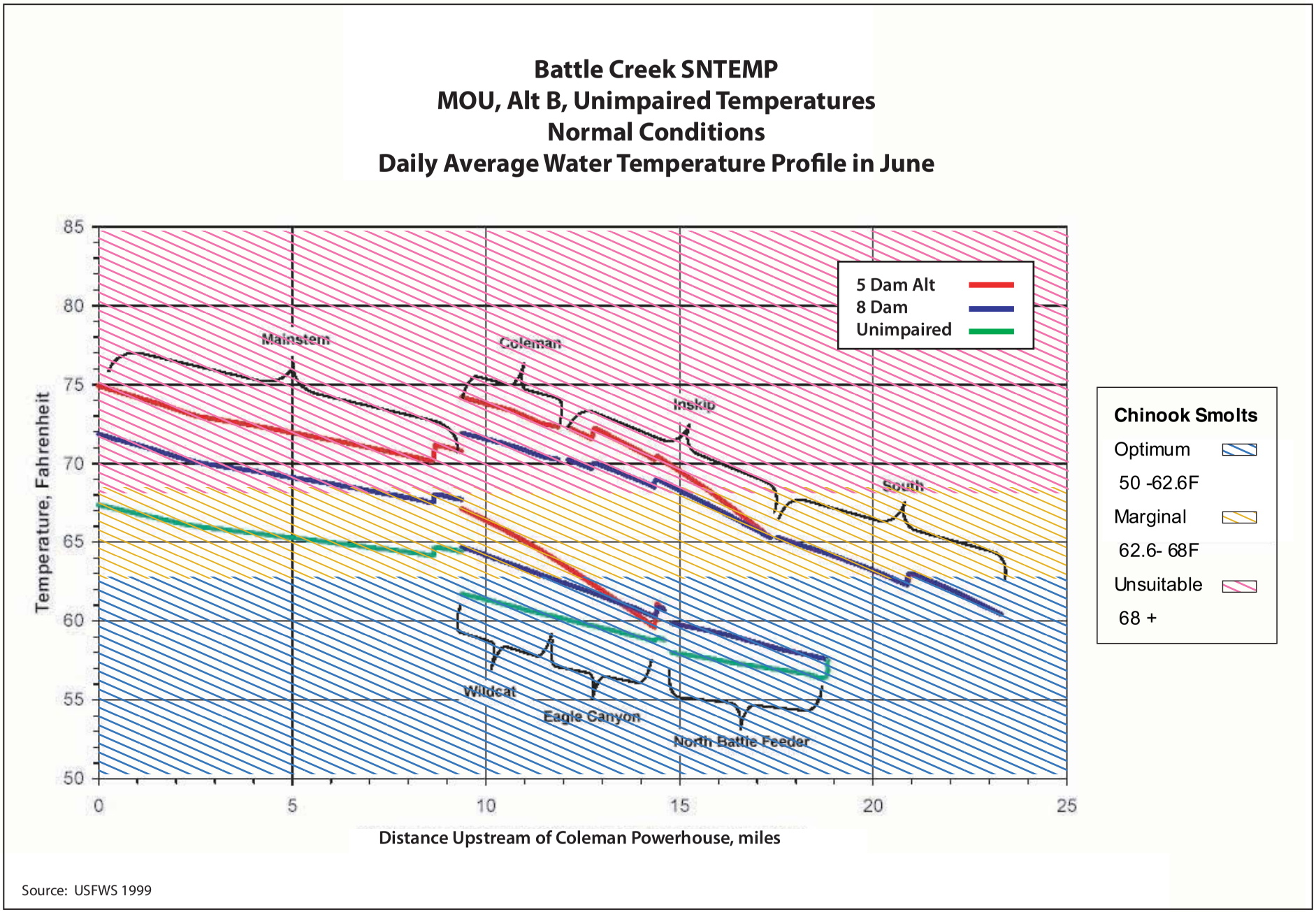
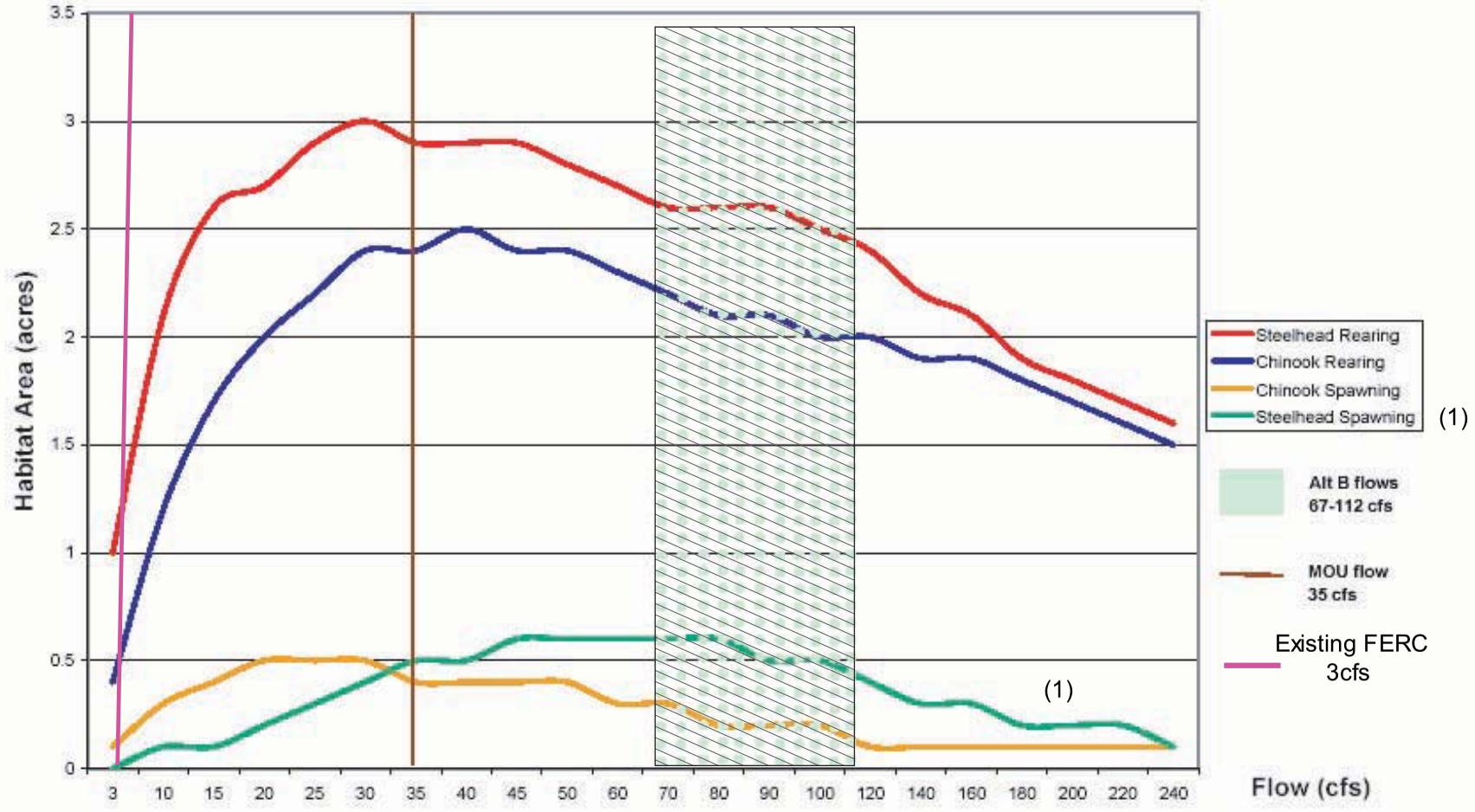


Figure 11
Chinook Smolt Survival
Normal Conditions (June)

MOU and Alt B Flow/Habitat Curves
June - Sep, Normal Year (1989)
North Fork Battle Creek, Eagle Canyon Reach



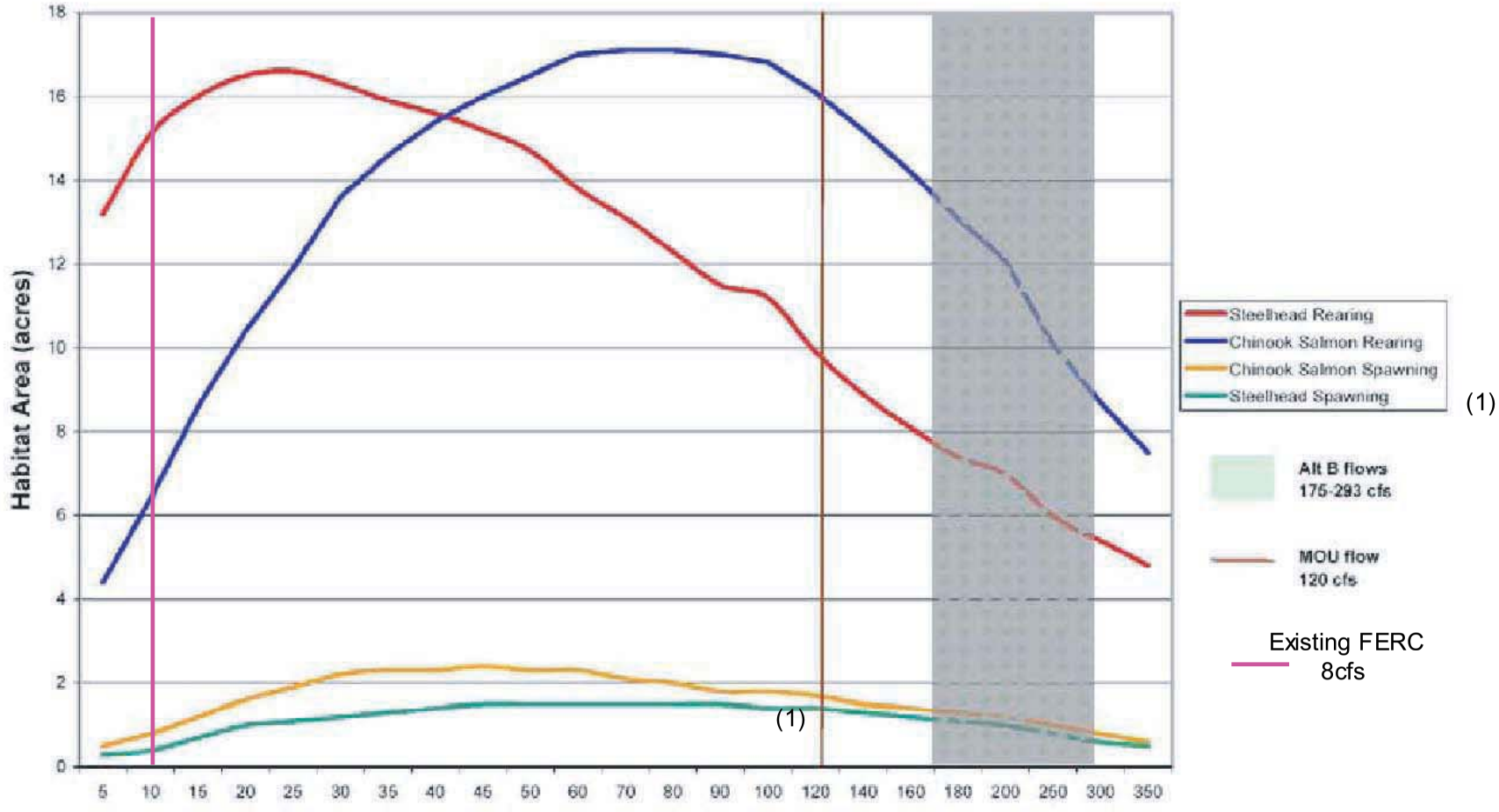
(1) Note Steelhead spawning occurs in winter so base flows approximate minimum winter flows between runoff events.

Source: USFWS 1999

03035.03 007 (09/04)

Figure 12
MOU and Alternative B Flow/Habitat Curves - Eagle Canyon Reach

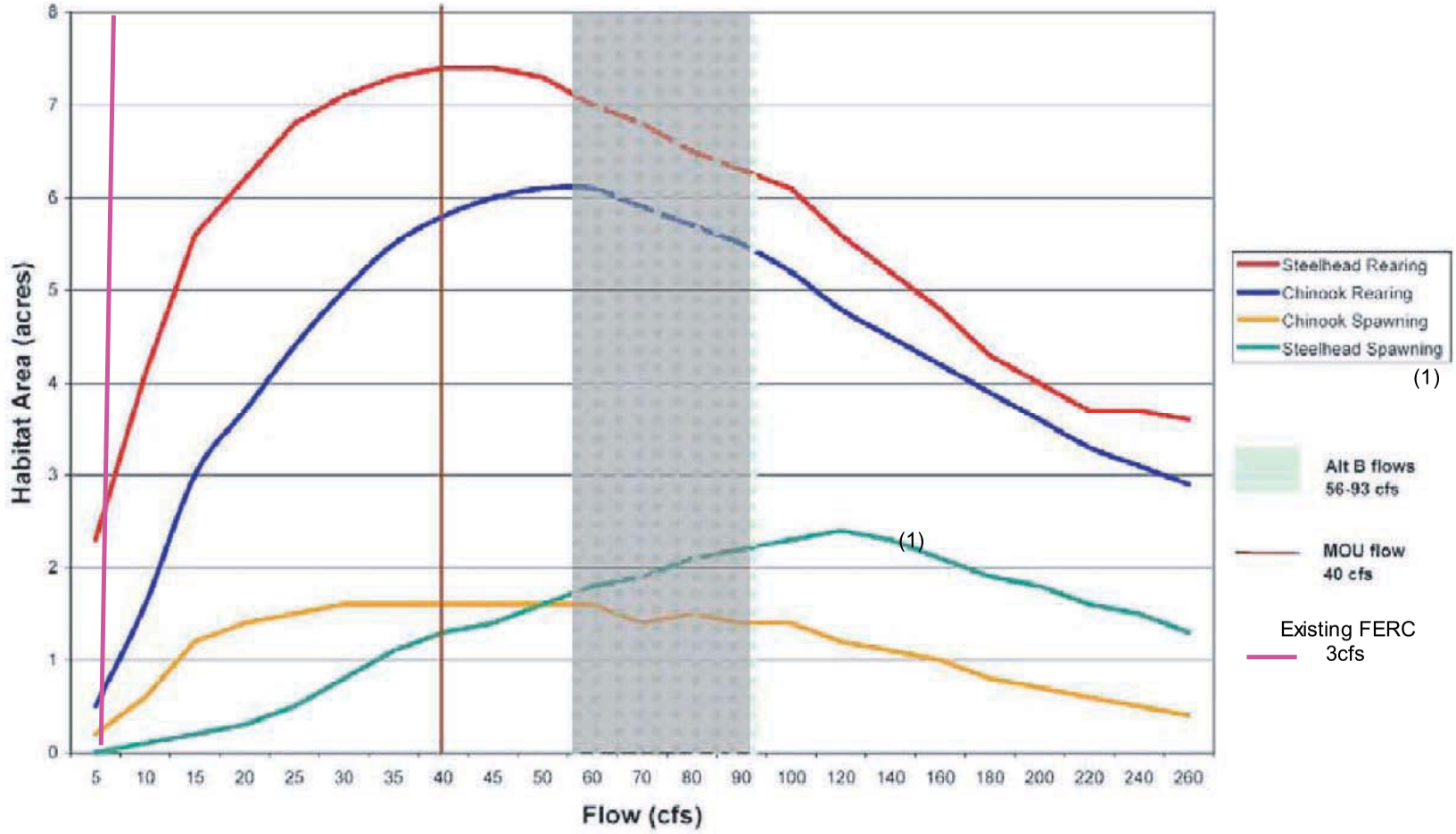
MOU and Alt B Flow/Habitat Curves
June - Sep, Normal Year (1989)
Mainstem Battle Creek Above Coleman PH



(1) Note Steelhead spawning occurs in winter so base flows approximate minimum winter flows between runoff events.

03035.03 007 (09/04)

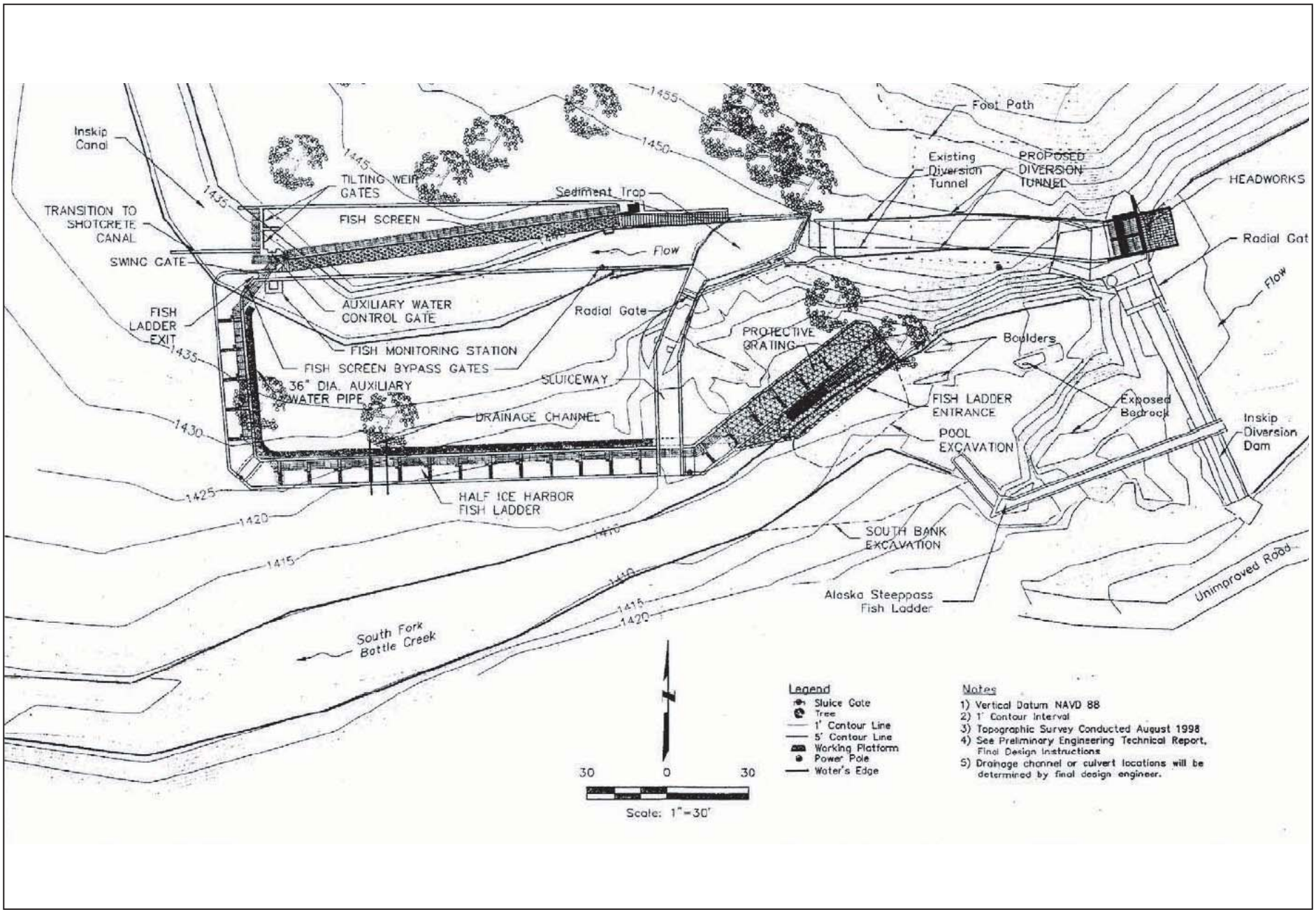
Figure 13
MOU and Alternative B Flow/Habitat Curves - Mainstem Battle Creek



(1) Note Steelhead spawning occurs in winter so base flows approximate minimum winter flows between runoff events.

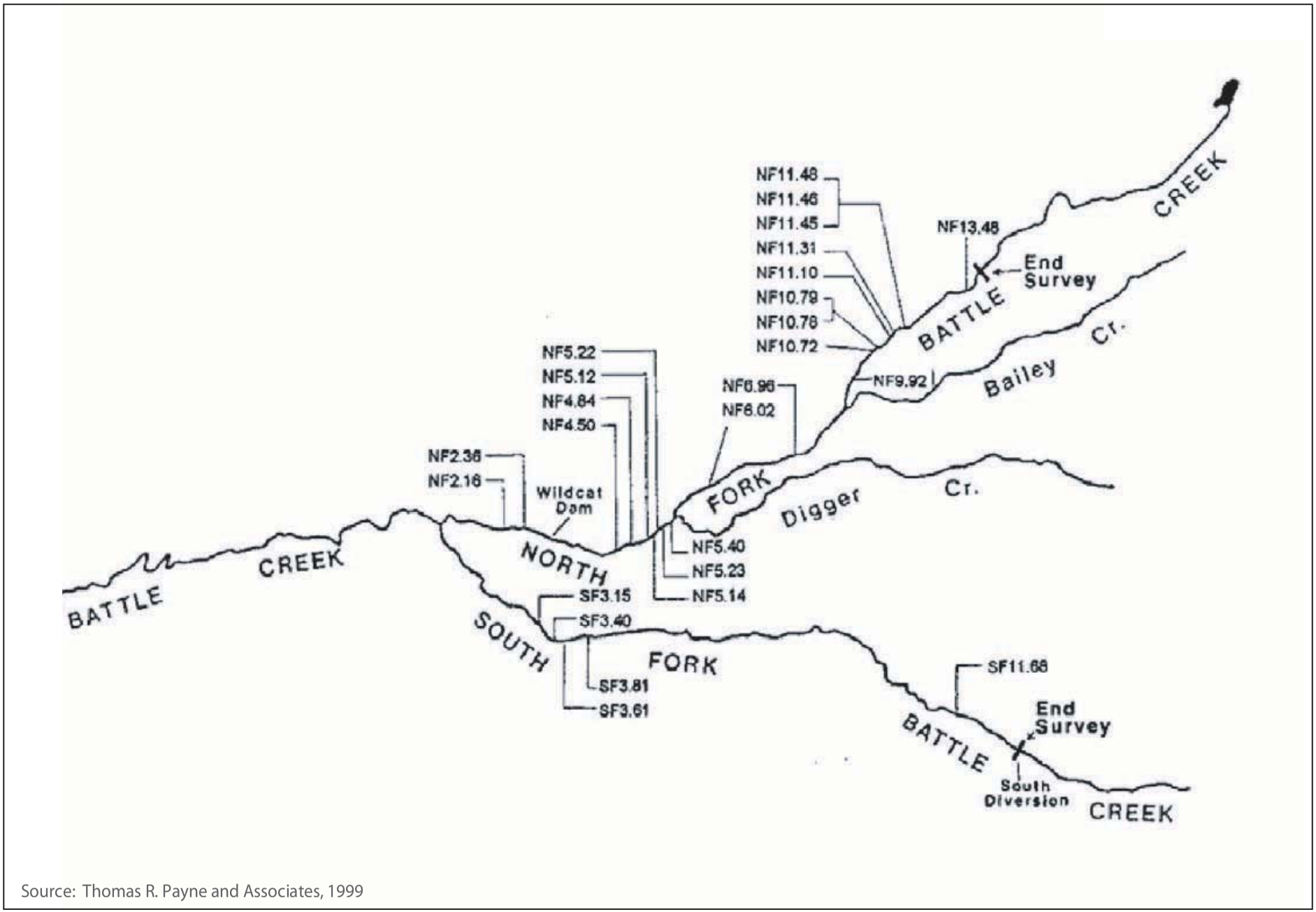
03035.03 007 (09/04)

Figure 14
MOU and Alternative B Flow/Habitat Curves—Inskip Reach



03035.03 007 (09/04)

Figure 15
Inskip Diversion Dam Fish Ladder Design



Source: Thomas R. Payne and Associates, 1999

03035.03 007 (09/04)

Figure 16
Natural Migration Obstacles Survey