Appendix M

Instream Flow Effects on Water Temperatures in the Battle Creek Restoration Area

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Introduction

Water temperature directly affects the quality of habitat used by various life stages of stream-resident fish. In Battle Creek, water temperatures are influenced by seasonal hydrological and meteorological conditions, diversions and powerhouse discharges into South Fork, and the instream flow releases below diversion dams, and the diversion of cold spring water from the stream channel (Kier Associates 1999; Thomas R. Payne and Associates 1998a, 1998b). The effects on fish populations are determined by the distribution of water temperatures within the stream habitat.

In this appendix, water temperatures are evaluated for the existing and No Action conditions and the four steelhead and salmon restoration alternatives. The habitat flows and hydroelectric power diversions have been simulated with a monthly model that is described in Appendix K. The temperatures at the upstream end of North Fork and South Fork have been obtained from field measurements. Warming estimates for each reach of Battle Creek that depend on the stream flow and month have been developed to approximate the measured temperatures obtained by DWR during the last five years (1998–2002) and data collected by TRPA in 1989.

The distribution of water temperature within the habitat of stream-resident fish affects their ability to effectively utilize that habitat. Natural temperature conditions in Central Valley streams vary along a continuum from mountain headwaters to lowland rivers (CALFED 2000), and populations of fishes have adapted to this natural continuum. Hydroelectric power diversions that divert relatively cool water from North Fork Battle Creek to South Fork Battle Creek may cool South Fork Battle Creek, but may also disrupt the temperature continuum. Habitat within these artificially cooled areas is considered to be of lower quality during months when it is disconnected from contiguous cool habitat. Furthermore, fish residing in artificially cooled areas are at risk of exposure to sub-optimal water temperatures during planned or unplanned disruptions in the hydropower conveyance system. The normal PG&E practice, however, in the Battle Creek system is to continue the diversion and canal flows, and allow the canal flow to bypass the powerhouse and flow into the river whenever the power plants are shut down.

Methods

Optimal Water Temperatures

Water temperatures are considered optimal when a number of physiological functions, including growth, swimming, feeding, and spawning are not limited. Optimal temperatures provide for normal feeding activity, normal physiological response, and normal behavior (McCullough 1999). The monthly fish life stage production model considers the optimal temperatures for spawning (and emerging fry) and the optimal rearing temperatures for steelhead and for chinook. The monthly survival rates for these two life stages are estimated from the monthly average temperature. Figure M-1 shows the assumed relationships.

For steelhead, optimal water temperatures for spawning and emerging fry are less than 53 ˚F. The monthly survival of incubating eggs is assumed to be less than 80% at a temperature of 56 ˚F. Because steelhead eggs incubate for at least two months, temperatures above 56 ˚F will result in much lower survival of fry. For chinook, the optimal spawning temperature is slightly warmer, with 100% survival below 55 ˚F, and less than 80% survival at 58 ˚F. For Steelhead rearing, the optimal temperature is less than 66 ˚F, with less than 80% monthly survival at a temperature of 70 ˚F. Because juvenile steelhead remain in the stream for an entire year, only a few months above 70 ˚F can be tolerated. Optimal rearing temperatures for chinook are assumed to be less than 65 ˚F, which is slightly cooler than for steelhead. The chinook monthly rearing survival is assumed to be less than 80% at a temperature of 69 ˚F.

For comparing the measured water temperatures in Battle Creek, ideal spawning temperatures would be less than 55 ˚F and ideal rearing temperatures would be less than 65 ˚F. A few months of up to 70 ˚F can be tolerated, but temperatures above 75 ˚F are considered to be unsuitable for steelhead or chinook rearing. These are relatively cool temperatures for streams flowing from the Sierra Nevada or Cascade Mountains into the Central Valley of California in the summer. Battle Creek is somewhat unique because of the large number of cool springs that feed the North Fork and South Fork, and the relatively deep canyon that provides shade on the North Fork.

Measured Water Temperatures

Water temperatures have been measured in Battle Creek during the IFIM studies in 1989 (Thomas R. Payne and Associates 1996a, 1996b) and during recent years by the DWR Northern District Office. These measured temperatures are shown and described here to provide an accurate description of water temperature patterns in the North Fork and South Fork of Battle Creek. Measurements are also available from the diversion canals and powerhouse tailwater, and in the mainstem Battle Creek below the confluence. No measurements have been collected in the springs that feed Battle Creek. The temperature measurements have been used to develop warming estimates for each reach of Battle Creek. These warming estimates were used in the monthly fish production model to estimate the likely future production of fish in each reach for each baseline and restoration alternative.

Water temperatures were collected on Battle Creek using data loggers in 1989 by Thomas R. Payne and Associates (1996a, 1996b) and from 1998-2001 by DWR Northern District. Hourly data was collected, and then reported as daily minimum, mean and maximum temperatures at several stations. Temperatures were analyzed to estimate warming which took place in each reach of Battle Creek during the warmer months of June through September. During this period, flows in both the North and South Forks of Battle Creek were generally less than about 30 cfs. Warming is expected to be less at higher flows. These historical temperature records were evaluated to estimate the general influence of flow on Battle Creek temperatures.

1989 Temperatures

Figure M-2 shows the water temperatures in Battle Creek for May through October 1989. The first graph shows water temperatures in the North Fork. Temperatures in the first reach from Feeder Dam to Eagle Canyon Diversion Dam ranged from about 55 °F to 60 °F in July, the warmest month. Warming in this reach was about 3 °F in June and rose gradually to about 5 °F by September. The second reach is from Eagle Canyon Diversion Dam to Wildcat Diversion Dam. Warming in this reach was stronger. Beginning with about 2 °F in May, it rose to about 10 °F during July, and then declined back to about 2 °F in October. The third reach is from Wildcat Diversion Dam to near the mouth of the North Fork confluence. This reach experienced very little warming. Changes in temperature were less than 1 °F.

The second graph of Figure M-2 shows water temperatures in the South Fork for the May to October period. Temperatures in the first reach from South Diversion Dam to the South Powerhouse were about 50 °F in May and rose to about 60 °F by August. Warming in this reach was about 5 °F. The next reach is from Inskip Diversion Dam to the Inskip Powerhouse. There was no temperature data for Inskip Diversion Dam in 1989 but it was cooled by the South Powerhouse discharge and would have been similar to the South Powerhouse tailwater temperature. Temperatures above Inskip Powerhouse were 70 to 75 °F in July. The warming in July can be estimated as the difference between above Inskip Powerhouse and the South Powerhouse tailwater that was about 60 ˚F. Warming can be estimated to be about 10 to 15 ˚F. The third reach is from Coleman Diversion Dam to near the mouth of the South Fork. There was no temperature data for Coleman Diversion Dam in 1989. Temperatures at the mouth were similar to temperatures above Inskip Powerhouse. The Coleman Powerhouse and canal was shut-off during August and temperatures at the mouth were cooled by the Inskip Powerhouse discharge.

The third graph of Figure M-2 shows water temperatures in the mainstem of Battle Creek. There was no temperature data available for the confluence of the North and South Forks in 1989. The large drop in temperatures evident from above Coleman Powerhouse to Coleman Powerhouse tailwaters is the result of cooler water in the Coleman Canal entering the mainstem. The mainstem was cooled during August while the Coleman Powerhouse was turned off and Coleman Diversion Dam diversions were reduced.

Figure M-3 shows the water temperatures in three of the power diversion canals. The first graph shows the temperatures in the Cross Country Canal and the South Battle Creek Canal. The Cross Country Canal is relatively cool North Fork water, while the South Battle Creek Canal is slightly warmer South Fork water. Accordingly, the temperatures at the South Powerhouse tailwater are between those of the two contributing canals. They ranged from about 55 to 60 °F during the summer period of June, July & August.

The second graph shows the temperatures in the Eagle Canyon Canal and the Inskip Canal. The temperature at the Inskip Powerhouse tailwater represents a blending of the two canals. Temperatures ranged from about 50 to 60 °F during the summer period of June to August.

The third graph shows the temperatures in the Coleman Canal. Warming in this canal was variable, from about 2 to 5 °F. For a period in August, warming jumped to about 6 to 8 °F. This change was the result of the Coleman Powerhouse experiencing an outage that lasted 23 days. With the powerhouse shut down, canal flow was apparently much lower and warming in the canal increased. The monthly temperatures and warming in each reach during 1989 are summarized in Table M-1.

1998 Temperatures

Figure M-4 shows average daily water temperatures in Battle Creek for 1998. The first graph shows temperatures in the North Fork. Temperatures in the North Fork remained below 60 °F for the entire year. Warming in the three North Fork reaches was very slight because of the generally high flows (Table M-2).

The second graph shows water temperatures in the South Fork. South Fork temperatures rose to about 65 °F in August. Warming from South Diversion Dam to the confluence (mouth) was less than 5 °F because of the high flows. Warming in the Coleman reach was about 1 °F in June and about 3 to 4 °F in August.

The third graph shows water temperatures in the mainstem of Battle Creek. Temperatures below the confluence of North and South Forks rose to about 60 °F in August. Warming in this reach was about 5 °F in July and August.

Figure M-5 shows the canal temperatures were less than 65 °F because the river diversion temperatures were generally cool in 1998. Table M-2 summarizes the monthly temperatures and warming measured in 1998.

1999 Temperatures

Figure M-6 shows the water temperatures in Battle Creek for 1999. The first graph shows the temperatures for the North Fork. Flows at Eagle Canyon Diversion Dam dropped to about 35 cfs in mid-June. Temperatures in the first reach rose to about 55 °F in July. Warming in this reach varied from 1 to 2 °F. Warming in the second reach was less than 3 °F. Warming in the third reach ranged from 1 to 3 °F (Table M-3).

The second graph shows water temperatures in the South Fork. After mid-June, flows in the South Fork dropped to less than 35 cfs. Temperatures in the first reach rose to about 60 °F by July. Warming in the South reach was about 4 °F for most of the period of lower flows. Warming in the Inskip reach varied from about 2 to 12 °F, with warming being over about 8 °F for most of the period of lower flows. Warming in the Coleman reach varied from about 1 to 4 °F, with warming being over about 3 °F for most of the period of lower flows (30 cfs interim flow).

The third graph shows water temperatures in the mainstem of Battle Creek. Temperatures below the confluence of North and South Forks rose to about 65 °F in July. Warming in the mainstem was about 1 °F in June and from about 3 to 5 °F in September. Temperatures upstream of the Coleman Powerhouse reached a maximum of about 70 °F in July and August. North Fork and South Fork flows were each about 30 cfs at the confluence.

Figure M-7 shows the water temperatures in three of the canals. The first graph shows the temperatures in the Cross Country Canal and the South Battle Creek Canal. The Cross Country Canal is relatively cool North Fork water, with temperatures that varied from about 50 to 60 °F during the June to September period. The South Battle Creek Canal is slightly warmer South Fork water, with temperatures that varied from about 50 to 65 °F during the summer.

The second graph shows the temperatures in the Eagle Canyon Canal and the Inskip Canal. The temperatures in Eagle Canyon Canal varied from 50 to 62 °F. The temperatures in Inskip Canal varied from about 47 to 61 °F.

The third graph shows the temperatures in the Coleman Canal. The temperatures in Coleman Canal varied from 50 to 65 °F during the summer. Table M-3 gives the monthly temperatures and warming estimates for 1999.

2000 Temperatures

Figure M-8 shows the water temperatures in Battle Creek for 2000. The first graph shows the temperatures for the North Fork. Flows at Eagle Canyon Diversion Dam dropped to about 30 cfs in late-June. Temperatures in the first reach rose to about 60 °F by the end of June. Warming in this reach varied from about 2.5 to 3 °F. Warming in the Eagle reach began about 2 °F in mid-July and declined to about 0.5 °F at the end of August. Warming in the Wildcat reach began about 3 °F in mid-July and declined to about 0.5 °F by the end of August.

The second graph shows water temperatures in the South Fork. Near the end of June, flows in the South Fork dropped to about 35 to 40 cfs. Temperatures in the first reach began about 50 °F and rose to about 65 °F by July. Warming in the first reach varied from about 4 to 5 °F. Warming in the Inskip reach was about 4 to 5 °F in June and rose to 12 to 14 °F in July and August, and then dropped to about 8 °F by the end of August. Warming in the Coleman reach varied from 1 to 2 °F because of the relatively high flow of 30 cfs.

The third graph shows water temperatures in the mainstem of Battle Creek. Temperatures below the confluence of North and South Forks rose to about 67 °F in August. Warming in the mainstem was about 2 to 4.5 °F in June, about 3.5 to 6 °F in July, and about 3 to 6.5 °F in August.

Figure M-9 shows the water temperatures in three of the canals. The Cross Country Canal temperatures varied from about 51 to 59 °F. The South Battle Creek Canal temperatures varied from about 54 to 66 °F. Accordingly, the temperatures at the South Powerhouse Tailwater ranged from about 52 to 60 °F.

The second graph shows the temperatures in the Eagle Canyon Canal and the Inskip Canal. Temperatures were generally 55 to 60 °F during the summer. The third graph shows the temperature changes in the Coleman Canal. Temperatures at Coleman Diversion Dam varied from about 55 to 65 °F. Warming in this canal was less than 2 °F with maximum temperatures of 65 °F. The Coleman Powerhouse temperatures were higher in early June because of the Powerhouse was out for several days. Table M-4 summarizes the monthly temperatures and warming in each Battle Creek reach for 2000.

2001 Temperatures

Figure M-10 shows the water temperatures in Battle Creek for 2001. The first graph shows the temperatures for the North Fork. Flows near the mouth of the North Fork were about 38 to 45 cfs for the period June to September. Temperatures at the Feeder Dam remained below 58 °F. Warming in the Feeder reach varied from about 2 to 3 °F. Warming in the Eagle reach was about 1 to 3 °F in June, about 2 to 3 °F in July and August, and about 1 to 2 °F in September. Warming in the Wildcat reach was about 1.5 to 3.5 °F in June, about

2.5 to 3.5 °F in July, declining to about 2 to 3 °F in August and 1 to 2 °F in September. North Fork temperatures remained below 65 °F at the mouth.

The second graph shows water temperatures in the South Fork. For most of the period June to September, flows in the South Fork were about 6 to 8 cfs. Temperatures in the South reach rose to about 62 °F by July. Warming in the first reach varied from about 12 °F in June, about 14 °F in July, 12 °F in August, and 9 °F in September. Warming in the Inskip reach was 9 °F in June, 10 °F in July and the beginning of August. At the end of September, warming was about 7 °F. South Fork temperatures at the mouth were 70 to 75 °F during the summer.

The third graph shows water temperatures in the mainstem of Battle Creek. Temperatures below the confluence were about 60 °F in June and rose to about 70 °F in July. Warming in the mainstem was only about 1 °F in June, because Coleman Powerhouse and canal was shut off. Warming was about 4 to 6 for July. Warming peaked at 7 to 8 °F in early August, and then gradually declined to 4 to 7 °F in September.

Figure M-11 shows the water temperatures in three of the canals. The first graph shows the temperatures in the Cross Country Canal and the South Battle Creek Canal. The Cross Country Canal temperatures varied from about 55 to 58 °F. The South Battle Creek Canal temperatures varied from about 56 to 64 °F. Temperatures at the South Powerhouse Tailwater ranged from about 54 to 60 °F. The second graph shows the temperatures in the Eagle Canyon Canal and the Inskip Canal. The temperatures in the Eagle Canyon Canal varied from about 56 to 60 °F. The temperatures in Inskip Canal varied from about 54 to 60 °F. The average warming in these canals was about 1 °F in early June, and then about 1 to 2.5 °F in August and early September. The third graph shows the temperatures in the Coleman Canal. Warming in the canal during August and early September was about 3 °F. Coleman Powerhouse was shut down during May and June. Table M-5 gives the monthly summary of 2001 temperatures and warming in each reach.

These temperature measurements from 5 years provide a very accurate description of water temperature conditions in Battle Creek. A wide range of flow conditions is included in the measurements. Temperatures at the upstream end of the restoration area will not be affected by the restoration alternatives. Temperatures in the other reaches can be influenced by instream flows, diversions, and powerhouse tailwater discharges. Warming estimates were developed from these measurements and used in the fish production modeling. The warming estimates will be described in the next section.

Modeling Methodology

Water temperatures in Battle Creek were modeled using SNTEMP, a cross-sectional averaged one-dimensional model, which was applied to the Battle Creek system including the natural stream channels and Hydroelectric Project canals (PG&E 2001a). Development of the SNTEMP model in Battle Creek, including calibration and partial validation, was primarily conducted in the late 1980s by Thomas R. Payne and Associates (1996a, 1996b). Additional development of the model, including re-calibration and validation, was conducted by Pacific Gas and Electric Company staff (2001b) to support development of the Battle Creek Salmon and Steelhead Restoration Project (Restoration Project).

The SNTEMP model simulated the Battle Creek temperature distribution, both spatially and temporally, using specifications of hydrology (dry, normal, and wet water years) and meteorology (hot, normal, and cold climate conditions). However, many of the inputs and assumptions of the SNTEMP model are not available without the computer files used for the modeling cases. The graphical results for the different restoration alternatives indicate the simulated warming in each reach. A simpler approach that would approximate the reach warming under any flow during the summer period was developed for use in the monthly fish production modeling. The development of this method and the comparison with the SNTEMP model output will be described in this section.

Battle Creek Warming Estimates

The upstream temperatures recorded at North Fork Feeder Dam and at South Diversion Dam have been fairly consistent from year to year. The restoration project will not influence the South Fork temperatures or flows upstream of South Diversion Dam. The temperatures at North Fork Battle Creek Feeder Diversion Dam are also assumed to be controlled by Bailey Creek and Rock Creek inflows. The restoration project does not include changing flows below the Keswick Diversion Dam, so the North Fork Battle Creek Feeder Diversion Dam temperatures are assumed to be unchanged by any restoration alternative. The monthly summer temperatures assumed at North Battle Creek Feeder dam are 56 ˚F in June, 57.5 ˚F in July, 56 ˚F in August, and 55 ˚F in September. At the South Diversion Dam the assumed monthly temperatures are slightly higher. The South Diversion Dam summer temperatures are assumed to be 60 ˚F in June, 62.5 ˚F in July, 62.5 ˚F in August, and 60 ˚F in September. All of the monthly temperatures used in the monthly modeling can be reviewed in Appendix L, “Results of the Monthly Flow and Power Model.”

Possible Effects of Flow on Temperature Warming

Warming in the summer months is assumed to be a direct function of the habitat flow. Higher flows will limit the warming. The greatest possible effect from increased flow is a direct inverse relationship with temperature:

Temperature Warming (˚F) = A / Flow (cfs)

If this relationship holds, then doubling the flow will reduce the warming to 50%. Increasing the flow by a factor of 10 will reduce the warming to 10%. This is the greatest possible effect because the higher flows will increase the volume and surface area of the stream reach and allow more heat exchange and a slightly longer travel time for warming to occur. This theoretical relationship will also assign the greatest benefit to the first increment of flow. For example increasing the South Fork flow from 5 cfs to 10 cfs would reduce the warming to 50% reduction of the existing warming. Increasing the flow to 20 cfs would reduce the warming to 25% of the existing warming. Increasing the flow to 40 cfs would reduce the warming to 12.5% of the existing warming. If the existing warming was 10 ºF in July and August, the increase from 5 cfs to 10 cfs would reduce the warming by 5 ºF. The increase in flow from 10 cfs to 20 cfs would reduce the warming by an additional 2.5 ºF. Increasing the flow from 20 cfs to 40 cfs would reduce the warming only by an additional 1.25 ºF.

A smaller estimated change in warming with flow was used in the monthly model. The warming in each reach is assumed to be proportional to the square root of flow:

$$\text{Warming (˚F)} = \text{A/ Flow (cfs)}^{0.5}$$

If this relationship holds, a 4x increase in flow (from 5 cfs to 20 cfs) would be required to reduce the warming to 50% of the existing warming at 5 cfs. An increase in flow from 5 cfs to 80 cfs (16x increase) would be required to reduce the warming to 25% of the existing warming. This assumed relationship will “even out” the potential temperature benefits from increased flow, and will require a greater increase in flow to achieve the same reduction in warming.

The warming observed in July and August is generally the highest. Warming in other months is assumed to be a simple fraction of the potential warming in July or August. Warming in June and September is assumed to be 80% of the maximum value for July or August. Warming in May and October is assumed to be 60% of the maximum value. Warming in April and November is assumed to be 40% of the maximum and warming in the other months is assumed to be 20%. This is a simple, yet effective, way to account for the change in meteorology throughout the year.

Measured Warming Relationships

Tables M-1 through M-5 provide a summary of the monthly temperatures measured in Battle Creek during the 5 years with data. For 1989, the measured warming between North Fork Battle Creek Feeder and Eagle Canyon Diversion Dam was about 4 ˚F in July and August with a flow of 5 cfs. The assumed warming equation is:

$$\text{Feeder Warming (˚F)} = 9 / \text{Flow (cfs)}^{0.5}$$

The warming at a flow of 5 cfs is 4 ˚F, and the warming with a flow of 20 cfs would be 2 ˚F. Unfortunately, the higher flows at North Fork Battle Creek Feeder Dam are not estimated from the stage records (limited stage-discharge rating curve) and so the validity of the warming relationship cannot be confirmed. The 1989 warming in the Eagle reach was about 8 ˚F at a flow of 4 cfs. The assumed Eagle warming equation is:

$$\text{Eagle Warming (˚F)} = 16 / \text{Flow (cfs)}^{0.5}$$

The warming at a flow of 5 cfs would be 7 ˚F, and the warming at a flow of 20 cfs would be 3.5 ˚F. Warming at a flow of 40 cfs would be 2.5 ˚F. The actual warming measured in 1999, 2000, and 2001 when the interim Eagle Canyon Diversion Dam Flow was between about 33 cfs and 40 cfs suggests that the warming was between 1.5 and 2.5 ˚F. This is less warming than would be expected from the assumed relationship, but more than would be expected if the alternative 1/flow warming equation was used. The observed warming was less than the 3 ˚F expected from the 35 cfs interim flow condition using the $1/\text{flow}^{0.5}$ warming equation.

The measured warming in the Wildcat reach was very small in 1989. The warming observed in the 1999–2001 period with interim flows of about 35–40 cfs was about 3–4 ˚F. The assumed warming equation for the Wildcat reach is:

$$\text{Wildcat Warming (˚F)} = 18 / \text{Flow (cfs)}^{0.5}$$

For the three South Fork reaches, similar warming equations were estimated. For the South reach in 1989 with a flow of 6 cfs the warming in July and August was about 6 ˚F. The warming was about 4–5 ˚F for flows of 6–7 cfs in the 1999–2001 measurements. The assumed warming in the South reach is:

$$\text{South Warming (˚F)} = 12 / \text{Flow (cfs)}^{0.5}$$

For the Inskip reach, the measured warming in June and July of 2000 and 2001 was about 10–14 ˚F for flows of about 8–10 cfs. During 1999 the warming was still 10 ºF for flows of 14–22 cfs. The assumed warming in the Inskip reach is:

$$\text{Inskip Warming (˚F)} = 40 / \text{Flow (cfs)}^{0.5}$$

The calculated warming will be 13 ˚F with a flow of 10 cfs and 9 ˚F with a flow of 20 cfs. The warming was reduced by about the expected amount between flows of 10 cfs and 20 cfs. An adaptive management experiment to measure temperatures while the flows are varied from 5 cfs to 10 cfs to 20 cfs to 40 cfs for about a week each during the July and August period would increase the accuracy of the Inskip warming estimates.

The measured warming in the Coleman reach was about 3 ˚F when the interim flows were 33-36 cfs in 1998–2000. The warming was about 9–10 ˚F in July and August of 2001 when the Coleman flows were reduced to 6 cfs to discourage fish from using the South Fork. The assumed Coleman reach warming is:

$$\text{Coleman Warming (˚F)} = 24 / \text{Flow (cfs)}^{0.5}$$

The mainstem warming in 2001 with a flow of 42 cfs was 5–7 ˚F in July and August. During July and August of 1999 and 2000 when the confluence flow was about 75 cfs, the measured warming was still 4–5 ˚F. The assumed mainstem warming between the confluence and upstream of the Coleman powerhouse is:

$$\text{Mainstem Warming (˚F)} = 42 / \text{Flow (cfs)}^{0.5}$$

The estimated warming with a flow of 10 cfs would be 13 ˚F. The estimated warming with a flow of 40 cfs would be 7 ˚F, and the estimated warming with a flow of 80 cfs would be 5 ˚F. These estimates match the measured warming in 1999 and 2000 when the confluence flow was about 75 cfs.

The Coleman warming estimate of 4 ˚F with a flow of 36 cfs is slightly higher than measured. The temperature-warming model used in the fish habitat assessment will calculate temperatures that are generally warmer than observed at higher flows. This will lead to conservative assessment of temperature benefits from alternative restoration actions because the actual temperatures may be slightly lower than calculated.

Temperatures along the North Fork Battle Creek have not been measured at Keswick Dam, so the temperatures in the Keswick reach are assumed to be the same as measured at North Battle Creek Feeder Diversion Dam. However, the temperatures at the North Battle Creek Feeder Diversion Dam may be largely influenced by the Rock Creek and Bailey Creek flows that enter North Fork Battle Creek just upstream of the North Battle Creek Feeder Diversion Dam. There may be substantial warming, therefore, below Keswick Dam at the minimum required FERC flows of only 3 cfs. A temperature measurement location should be established upstream of the Rock Creek confluence to identify this possible warming condition in the Keswick reach with relatively low flows.

A similar situation may exist at the Eagle Canyon Diversion Dam, where temperature measurements may be influenced by the Digger Creek flows that enters North Fork Battle Creek just upstream of the Eagle Canyon Diversion Dam. Temperature measurements at the mouth of Digger Creek in 2001 and 2002 were identical to the Eagle Canyon Diversion Dam measurements, with June and July temperatures of almost 60ºF. A temperature measurement location should be established upstream of Digger Creek to identify the potential warming in the North Battle Creek Feeder reach with relatively low flows.

Calculated Temperatures for 2000 and 2001

Figure M-10 shows the North Fork calculated and historical water temperatures for 2000. Warming in the Feeder reach was about 2 to 3 ˚F. The calculated temperatures at Eagle Canyon Diversion Dam matched this warming. Warming in the Eagle reach was about 1 to 2 ˚F. The calculated temperatures at Wildcat Diversion Dam were about 1 ˚F less than the historical record. Warming in the Wildcat reach was about 1 to 3 ˚F. The calculated temperatures at the mouth were about 1 ˚F higher than the historical record. Warming in the mainstem reach was about 3–5 ˚F during the summer months. The calculated warming in the mainstem reach were similar, although calculated temperatures at the Coleman Powerhouse were higher than the historical data. Overall, the calculated temperatures provide a reasonable approximation of the measured data during the year.

Figure M-11 shows the South Fork calculated and historical water temperatures for 2000. Warming in the South reach was about 4 ˚F. The calculated temperatures at the South Powerhouse matched this warming. Warming in the Inskip reach was about 8 to 12 ˚F. The calculated temperatures at the Inskip Powerhouse matched this warming. The calculated temperatures in July, August, and September produced more warming than the historical record. Warming in the Coleman reach was about 1 to 3 ˚F because of the interim flow of 30 cfs. The calculated temperatures at the mouth produced about 3 ˚F more warming than the historical record. The calculated South Fork temperatures generally matched the 2000 data.

Figure M-12 shows the North Fork calculated and historical water temperatures for 2001. Warming in the Feeder reach was about 2 ˚F. The calculated temperatures at Eagle Canyon Diversion Dam matched this warming in June and September, but produced about 1 ˚F more warming than the historical record in July and August. Warming in the Eagle reach was about 2 ˚F. The calculated temperatures at Wildcat Diversion Dam matched this warming in June, but were about 1 ˚F higher than the historical data in July through September. Warming in the Wildcat reach was about 2 to 3 ˚F. The calculated temperatures at the mouth matched this warming in June and July, but produced about 1 ˚F more warming than the historical record in August and September. The warming in the mainstem reach was about 3 to 6 ˚F. The calculated temperatures at the Coleman Powerhouse were about 3 to 4 ˚F higher than the historical data in June and July, and about 1 ˚F higher than the historical record in August and September. Overall the match of the calculated temperatures with the 2001 data was good.

Figure M-13 shows the South Fork calculated and historical water temperatures for 2001. Warming in the South reach was about 5 ˚F. The calculated temperatures at the South Powerhouse matched the data in July and August, but were about 1 ˚F cooler than the historical record in June and September. Warming in the Inskip reach was about 9 to 13 ˚F. The calculated temperatures at the Inskip Powerhouse were about 1 ˚F less than the historical record in June and July, but matched the data in August and September. Warming in the Coleman reach was about 7 to 10 ˚F. The calculated temperatures at the mouth matched this warming, but were about 1 ˚F higher than the historical record in July through September.

The releases below Coleman Diversion Dam were greater than 30 cfs in 2000 (Interim flows) but were reduced to about 8 cfs in 2001. The warming estimates in 2000 were a little higher than measured. The warming estimates in 2001 when the flows were reduced were very close to measurements. The assumed warming relationship with 1/flow $^{0.5}$ may overestimate the actual warming at higher flows.

These two years of data suggest that the monthly temperature estimates are adequate for accurate assessment of the temperature effects from flow changes in Battle Creek.

Calculating Monthly Temperature Survival

Many of the Battle Creek reaches have a wide range of temperatures from a relatively cool temperature at the upstream end to a warmer temperature at the downstream end. The monthly fish production model assumed a linear effect of temperature and calculated the survival at the cooler upstream end and the survival at the warmer downstream end. An average survival was used for fish in the reach.

No direct comparisons of the average reach temperatures for the different alternatives were made, because the effects of temperature on fish survival was accounted for in the fish production model. The fish production model was run with all temperatures assumed to be ideal (below 53 ˚F) to estimate the fish production without any temperature limits. Comparison of the change in fish production when temperatures are included in the calculations provides a direct indication of the magnitude of the potential temperature effects for each alternative. The calculated reduction in fish production from temperature effects was quite large for several of the alternatives. The winter run and spring run chinook are most severely limited by temperatures. Temperature change is not considered a significant impact itself unless the potential fish production is reduced by the warmer temperatures.

Battle Creek Temperature Results

The monthly temperatures calculated for each restoration alternative for the range of Battle Creek flows in each reach are given in Tables M-6 through M-11. The consequences of water temperatures for minimum instream flow requirements on fish populations are described in Section 4.1, “Fish.”

Table M-1a. North Fork Battle Creek Warming Estimates, 1989

	June	July	August	September
Flows (cfs)				
North Battle Creek Feeder	30+	5	5	4
Eagle Canyon	4	4	4	4
Wildcat	6	6	6	6
Temperatures (˚F)				
North Battle Creek Feeder	56.1	56.6	55.3	53.5
Eagle Canyon	59.5	60.3	59.6	57.9
Wildcat	64.4	69.2	67.1	61.9
Mouth	64.2	68.7	67.1	62.6
ΔT				
North Battle Creek Feeder – Eagle	3.4	3.7	4.3	4.4
Eagle – Wildcat	4.9	8.9	7.5	4.0
Wildcat – Mouth	-0.2	-0.5	0.0	0.7

Table M-1b. South Fork Battle Creek Warming Estimates, 1989

	June	July	August	September
Flows (cfs)				
South	6	6	6	6
Inskip	7	6	6	7
Coleman	8	7	7	7
Temperatures (˚F)				
South	58.5	58.9	57.2	54.4
above South Powerhouse	64.4	65.1	63.4	59.8
Inskip	--	--	--	--
above Inskip Powerhouse	63.4	72.1	69.4	63.4
Coleman	--	--	--	--
Mouth	64.2	65.1	59.9	60.0
ΔT				
South – above South Powerhouse	5.9	6.2	6.2	5.4
Inskip – above Inskip Powerhouse	--	--	--	--
Coleman – Mouth	--	--	--	--

Table M-2a. North Fork Battle Creek Warming Estimates, 1998

	June	July	August	September
Flows (cfs)				
North Battle Creek Feeder	30+	30+	30+	30+
Eagle	30+	30+	30+	30+
Wildcat	30+	30+	30+	30+
Temperatures (˚F)				
North Battle Creek Feeder	51.8	56.1	57.9	52.7
Eagle	52.8	57.2	58.0	56.3
Wildcat	--	58.5	59.3	57.7
Mouth	54.2	59.4	60.8	56.1
ΔT				
North Battle Creek Feeder – Eagle	1.0	1.1	0.1	3.6
Eagle – Wildcat	--	1.3	1.3	1.4
Wildcat – Mouth	--	0.9	1.5	-1.6

Table M-2b. South Fork Battle Creek Warming Estimates, 1998

	June	July	August	September
Flows (cfs)				
South	30+	30+	7	7
Inskip	30+	30+	35	25
Coleman	30+	30+	33	33
Temperatures (˚F)				
South	50.9	58.9	--	54.1
above South Powerhouse	--	--	--	--
Inskip	54.3	60.0	--	53.8
above Inskip Powerhouse	--	--	--	--
Coleman	55.4	60.3	60.8	55.0
Mouth	54.7	63.4	63.9	59.0
ΔT				
South – above South Powerhouse	--	--	--	--
Inskip – above Inskip Powerhouse	--	--	--	--
Coleman – Mouth	-0.7	3.1	3.1	4.0

Table M-3a. North Fork Battle Creek Warming Estimates, 1999

	June	July	August	September
Flows (cfs)				
North Battle Creek Feeder	30+	30+	6	5
Eagle	30+	35	33	33
Wildcat	30+	40	36	36
Temperatures (˚F)				
North Battle Creek Feeder	54.1	56.8	56.0	54.6
Eagle	55.7	58.5	57.7	56.2
Wildcat	56.9	60.2	59.8	57.8
Mouth				
ΔT				
North Battle Creek Feeder – Eagle	1.6	1.7	1.7	1.6
Eagle – Wildcat	1.2	1.7	2.1	1.6
Wildcat – Mouth	-2.2	3.2	4.1	1.2

Table M-3b. South Fork Battle Creek Warming Estimates, 1999

	June	July	August	September
Flows (cfs)				
South	30+	7	6	7
Inskip	49	22	14	11
Coleman	38	36	36	35
Temperatures (˚F)				
South	57.5	61.9	60.5	57.7
above South Powerhouse	60.6	66.3	64.7	61.5
Inskip	57.1	59.2	58.0	55.8
above Inskip Powerhouse	61.8	68.9	68.1	64.0
Coleman	58.6	60.7	59.5	57.2
Mouth	60.6	63.9	62.0	58.7
ΔT				
South – above South Powerhouse	3.1	4.4	4.2	3.8
Inskip – above Inskip Powerhouse	4.7	9.7	10.1	8.2
Coleman – Mouth	2.0	3.2	2.5	1.5

Table M-4a. North Fork Battle Creek Warming Estimates, 2000

	June	July	August	September
Flows (cfs)				
North Battle Creek Feeder	30+	5	5	5
Eagle	10	34	37	38
Wildcat	47	37	40	41
Temperatures (˚F)				
North Battle Creek Feeder	55.9	56.6	55.9	53.2
Eagle	--	59.6	58.6	55.6
Wildcat	59.2	61.5	60.0	56.4
Mouth	--	64.2	62.2	57.5
ΔT				
North Battle Creek Feeder – Eagle	--	3.0	2.7	2.4
Eagle – Wildcat	--	1.9	1.4	0.8
Wildcat – Mouth	--	2.7	2.2	1.1

Table M-4b. South Fork Battle Creek Warming Estimates, 2000

	June	July	August	September
Flows (cfs)				
South	7	6	7	6
Inskip	32	10	8	8
Coleman	30+	39	33	33
Temperatures (˚F)				
South	61.2	62.1	61.2	55.7
above South Powerhouse	65.3	66.6	65.5	59.6
Inskip	59.1	59.1	58.4	53.6
above Inskip Powerhouse	66.9	70.9	70.1	61.8
Coleman	60.9	61.1	60.5	55.5
Mouth	62.1	63.3	63.3	57.5
ΔT				
South – above South Powerhouse	4.1	4.5	4.3	3.9
Inskip – above Inskip Powerhouse	7.8	11.8	11.7	8.2
Coleman – Mouth	1.2	2.2	2.8	2.0

Table M-5a. North Fork Battle Creek Warming Estimates, 2001

	June	July	August	September
Flows (cfs)				
North Battle Creek Feeder	--	--	--	--
Eagle	34	33	33	33
Wildcat	37	36	36	36
Temperatures (˚F)				
North Battle Creek Feeder	55.6	56.7	56.1	54.6
Eagle	58.1	59.2	58.6	56.9
Wildcat	60.1	61.8	60.9	58.6
Mouth	62.7	64.8	63.6	60.4
ΔT				
North Battle Creek Feeder – Eagle	2.5	2.5	2.5	2.3
Eagle – Wildcat	2.0	2.6	2.3	1.7
Wildcat – Mouth	2.6	3.0	2.7	1.8

Table M-5b. South Fork Battle Creek Warming Estimates, 2001

	June	July	August	September
Flows (cfs)				
South	--	--	--	--
Inskip	8	8	9	9
Coleman	6	6	6	6
Temperatures (˚F)				
South	59.6	61.7	60.2	56.8
above South Powerhouse	64.9	67.0	65.4	61.7
Inskip	58.0	60.0	59.0	56.5
above Inskip Powerhouse	69.7	73.6	71.2	65.3
Coleman	59.6	62.0	61.3	57.6
Mouth	68.8	72.0	69.9	64.9
ΔT				
South – above South Powerhouse	5.3	5.3	5.2	4.9
Inskip – above Inskip Powerhouse	11.7	13.6	12.2	8.8
Coleman – Mouth	9.2	10.0	8.6	7.3

Table M-6. Temperature Results for No Action Baseline (FERC Flows)

Range of Flow (%)	Temperature (ºF)											
	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec
At North Fork Battle Creek Feeder Assumed												
	45.0	45.0	47.5	52.5	55.0	56.0	57.5	56.0	55.0	52.5	50.0	45.0
At Eagle Canyon Diversion Dam												
10	45.7	45.7	48.2	53.9	57.1	58.8	61.0	59.5	57.8	54.6	51.4	45.7
30	45.3	45.2	47.7	53.0	56.5	58.8	61.0	59.5	57.8	54.6	51.4	45.7
50	45.1	45.1	47.6	52.8	55.4	57.2	61.0	59.5	57.8	54.6	51.4	45.3
70	45.1	45.1	47.6	52.7	55.3	56.7	60.3	59.5	57.8	54.6	50.7	45.1
90	45.1	45.1	47.6	52.7	55.3	56.4	59.2	59.5	57.8	54.6	50.2	45.1
At Wildcat Diversion Dam												
10	47.4	47.4	49.9	57.3	62.3	65.7	69.6	68.1	64.7	59.8	54.8	47.4
30	46.3	45.7	48.1	54.2	61.6	65.7	69.6	68.1	64.7	59.8	54.8	47.4
50	45.5	45.4	47.9	53.4	56.4	60.9	69.6	68.1	64.7	59.8	54.8	46.0
70	45.3	45.3	47.8	53.2	56.0	58.4	69.0	68.1	64.7	59.8	53.3	45.5
90	45.2	45.2	47.7	53.0	55.9	57.4	65.8	68.1	64.7	59.8	50.7	45.2
North Fork Battle Creek at Confluence												
10	49.2	49.2	51.7	60.8	67.5	72.6	78.3	76.8	71.6	65.0	58.3	49.2
30	47.9	46.1	48.5	55.5	66.8	72.6	78.3	76.8	71.6	65.0	58.3	49.2
50	45.8	45.7	48.1	54.0	57.4	66.0	78.3	76.8	71.6	65.0	58.3	46.8
70	45.5	45.5	48.0	53.7	56.7	60.2	77.7	76.8	71.6	65.0	56.8	45.8
90	45.4	45.4	47.8	53.3	56.5	58.3	74.4	76.8	71.6	65.0	51.1	45.4
Above South Diversion Dam Assumed												
	45.0	45.0	47.5	50.0	55.0	60.0	62.5	62.5	60.0	55.0	50.0	45.0
Above South Powerhouse												
10	46.1	46.1	48.6	52.1	58.2	64.3	67.9	67.9	64.3	58.2	52.1	46.1
30	45.8	45.5	48.0	51.2	58.2	64.3	67.9	67.9	64.3	58.2	52.1	46.1
50	45.4	45.4	47.8	50.8	56.2	63.0	67.9	67.9	64.3	58.2	52.1	45.7
70	45.3	45.3	47.8	50.6	55.9	62.0	67.9	67.9	64.3	58.2	51.7	45.4
90	45.2	45.2	47.7	50.4	55.8	61.2	66.7	67.9	64.3	58.2	50.6	45.2
At Inskip Diversion Dam												
10	45.7	45.7	48.1	52.5	56.3	59.1	61.1	60.0	58.2	54.6	51.0	45.8
30	45.7	45.6	48.0	52.2	56.3	59.2	61.2	60.3	58.3	54.7	51.0	45.7
50	45.6	45.5	48.0	52.0	56.0	59.2	61.4	60.3	58.4	54.8	51.0	45.6
70	45.5	45.5	47.9	51.8	55.9	59.3	61.6	60.5	58.5	54.8	50.9	45.6
90	45.4	45.4	47.8	51.5	55.9	59.5	61.6	60.6	58.6	54.9	50.7	45.4

Range of Flow (%)	Temperature (ºF)											
	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Above Inskip Powerhouse												
10	48.8	48.8	51.2	58.5	65.4	71.3	76.3	75.2	70.4	63.8	57.1	48.9
30	46.6	46.4	48.8	54.0	60.4	71.3	76.4	75.5	70.5	63.8	57.1	48.8
50	46.3	46.2	48.6	53.4	58.1	62.9	76.6	75.5	70.6	63.9	55.6	46.5
70	46.0	46.0	48.4	53.0	57.7	62.4	69.3	75.7	70.6	63.9	52.8	46.3
90	45.8	45.9	48.2	52.4	57.5	61.8	66.3	75.8	70.7	59.3	51.8	45.9
At Coleman Diversion Dam												
10	45.4	45.4	47.8	52.9	57.1	60.1	62.2	60.7	58.5	54.6	50.9	45.2
30	45.5	45.5	47.9	52.9	57.3	60.3	62.5	61.3	58.9	55.0	51.1	45.4
50	45.5	45.5	47.9	52.7	57.1	60.6	63.0	61.5	59.1	55.3	51.4	45.5
70	45.5	45.5	47.9	52.5	57.0	60.5	63.6	61.9	59.4	55.5	51.4	45.5
90	45.5	45.5	47.9	52.2	56.9	60.7	63.4	62.2	59.6	55.8	51.2	45.5
South Fork Battle Creek at Confluence												
10	48.7	48.7	51.0	59.3	66.7	73.0	78.3	76.8	71.4	64.2	57.3	48.4
30	48.8	47.1	49.3	57.3	67.0	73.1	78.6	77.4	71.8	64.7	57.5	48.7
50	46.6	46.4	48.7	54.7	60.1	73.4	79.1	77.6	72.0	65.0	57.8	48.5
70	46.1	46.1	48.5	54.0	59.1	66.2	79.7	78.0	72.2	65.1	57.9	46.6
90	45.9	46.0	48.3	53.3	58.8	63.6	79.5	78.3	72.5	65.5	52.6	46.0
At Confluence												
10	48.8	48.8	51.3	59.9	67.0	72.8	78.3	76.8	71.5	64.5	57.7	48.7
30	48.4	46.5	48.8	56.1	66.9	72.9	78.5	77.2	71.7	64.8	57.8	48.8
50	46.1	46.0	48.4	54.3	58.4	69.5	78.8	77.3	71.9	65.0	58.0	47.3
70	45.7	45.7	48.2	53.8	57.6	62.4	78.9	77.6	72.0	65.1	57.5	46.1
90	45.6	45.6	48.0	53.3	57.4	60.3	77.6	77.7	72.2	65.3	51.7	45.6
Above Coleman Powerhouse												
10	51.8	51.8	54.2	65.8	75.9	84.7	93.1	91.7	83.4	73.4	63.6	51.7
30	51.2	47.6	49.8	59.1	75.9	84.8	93.3	92.0	83.6	73.7	63.8	51.8
50	46.9	46.6	49.0	55.7	60.6	79.9	93.6	92.2	83.7	73.9	64.0	49.3
70	46.2	46.2	48.7	54.9	59.2	66.4	93.8	92.4	83.9	74.0	63.4	46.9
90	45.9	46.0	48.3	54.1	58.7	62.4	92.5	92.6	84.1	74.2	52.7	46.0
At Coleman National Fish Hatchery												
10	46.3	46.3	48.4	53.5	57.6	60.7	62.7	61.3	59.1	55.2	51.6	46.1
30	46.3	46.3	48.5	53.5	57.9	60.8	63.1	62.0	59.5	55.7	51.8	46.3
50	46.3	46.3	48.5	53.2	57.5	61.2	63.7	62.2	59.7	56.0	52.1	46.3
70	46.4	46.4	48.5	53.1	57.3	61.0	64.3	62.7	59.9	56.1	52.1	46.3
90	46.4	46.4	48.5	52.7	57.2	60.9	64.2	62.9	60.3	56.5	51.8	46.4

Table M-7. Temperature Results for Five Dam Removal Alternative

Range of Flow (%)	Temperature (ºF)											
	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec
At North Fork Battle Creek Feeder Assumed												
	45.0	45.0	47.5	52.5	55.0	56.0	57.5	56.0	55.0	52.5	50.0	45.0
At Eagle Canyon Dam												
10	45.2	45.2	47.7	52.8	55.5	56.8	58.6	57.2	55.9	53.2	50.4	45.2
30	45.2	45.1	47.6	52.8	55.5	56.7	58.5	57.1	55.9	53.2	50.4	45.2
50	45.1	45.1	47.6	52.8	55.4	56.7	58.4	57.0	55.8	53.1	50.4	45.1
70	45.1	45.1	47.6	52.7	55.3	56.7	58.4	56.9	55.8	53.1	50.4	45.1
90	45.1	45.1	47.6	52.7	55.3	56.4	58.4	56.9	55.7	53.0	50.2	45.1
At Wildcat Diversion Dam												
10	45.6	45.6	48.1	53.7	57.0	58.8	61.1	59.7	57.9	54.8	51.4	45.6
30	45.5	45.5	48.0	53.5	57.0	58.7	61.1	59.6	57.9	54.7	51.4	45.6
50	45.4	45.4	47.9	53.4	56.4	58.6	61.0	59.6	57.8	54.6	51.4	45.5
70	45.3	45.3	47.8	53.2	56.0	58.4	60.9	59.5	57.8	54.6	51.3	45.4
90	45.2	45.2	47.7	53.0	55.9	57.4	60.8	59.4	57.7	54.5	50.7	45.2
North Fork Battle Creek at Confluence												
10	46.0	46.0	48.5	54.5	58.4	60.5	63.3	61.9	59.7	56.1	52.3	46.0
30	45.9	45.8	48.3	54.2	58.4	60.5	63.3	61.8	59.6	56.0	52.3	46.0
50	45.7	45.7	48.1	54.0	57.3	60.2	63.1	61.8	59.6	55.9	52.2	45.9
70	45.5	45.5	48.0	53.7	56.7	59.9	63.1	61.7	59.6	55.9	52.1	45.7
90	45.4	45.4	47.8	53.3	56.5	58.3	62.8	61.6	59.5	55.8	51.1	45.4
Above South Diversion Dam Assumed												
	45.0	45.0	47.5	50.0	55.0	60.0	62.5	62.5	60.0	55.0	50.0	45.0
Above Powerhouse												
10	45.3	45.3	47.8	50.7	56.0	61.5	64.7	65.0	61.9	56.4	50.8	45.4
30	45.3	45.3	47.8	50.5	55.9	61.4	64.5	64.7	61.7	56.2	50.7	45.3
50	45.2	45.2	47.7	50.5	55.7	61.1	64.3	64.5	61.6	56.1	50.6	45.3
70	45.2	45.2	47.7	50.4	55.6	61.0	64.0	64.3	61.5	56.0	50.6	45.2
90	45.2	45.2	47.7	50.4	55.6	60.9	63.9	64.2	61.4	55.9	50.4	45.2
At Inskip Diversion Dam												
10	45.3	45.3	47.8	50.7	56.0	61.5	64.7	65.0	61.9	56.4	50.8	45.4
30	45.3	45.3	47.8	50.5	55.9	61.4	64.5	64.7	61.7	56.2	50.7	45.3
50	45.2	45.2	47.7	50.5	55.7	61.1	64.3	64.5	61.6	56.1	50.6	45.3
70	45.2	45.2	47.7	50.4	55.6	61.0	64.0	64.3	61.5	56.0	50.6	45.2
90	45.2	45.2	47.7	50.4	55.6	60.9	63.9	64.2	61.4	55.9	50.4	45.2

Range of Flow (%)	Temperature (ºF)											
	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Above Inskip Powerhouse												
10	46.1	46.1	48.6	52.4	59.2	65.8	70.1	70.3	66.2	59.6	53.0	46.2
30	46.0	46.0	48.5	52.3	59.1	65.7	69.9	70.0	66.0	59.4	52.9	46.1
50	46.0	45.9	48.4	51.9	57.9	65.4	69.7	69.9	65.9	59.3	52.8	46.0
70	45.7	45.7	48.2	51.6	57.4	64.3	69.4	69.7	65.8	59.3	52.7	46.0
90	45.6	45.6	48.1	51.3	57.2	63.2	69.3	69.6	65.7	59.1	51.6	45.6
At Coleman Diversion Dam												
10	46.1	46.1	48.6	52.4	59.2	65.8	70.1	70.3	66.2	59.6	53.0	46.2
30	46.0	46.0	48.5	52.3	59.1	65.7	69.9	70.0	66.0	59.4	52.9	46.1
50	46.0	45.9	48.4	51.9	57.9	65.4	69.7	69.9	65.9	59.3	52.8	46.0
70	45.7	45.7	48.2	51.6	57.4	64.3	69.4	69.7	65.8	59.3	52.7	46.0
90	45.6	45.6	48.1	51.3	57.2	63.2	69.3	69.6	65.7	59.1	51.6	45.6
South Fork Battle Creek at Confluence												
10	46.8	46.8	49.3	54.2	62.4	70.0	75.4	75.7	70.5	62.8	55.1	47.1
30	46.8	46.7	49.2	54.0	62.3	70.0	75.3	75.4	70.3	62.7	55.0	46.8
50	46.7	46.6	49.0	53.3	60.0	69.7	75.0	75.3	70.2	62.5	54.9	46.8
70	46.3	46.3	48.8	52.9	59.2	67.7	74.8	75.1	70.1	62.5	54.9	46.7
90	46.0	46.1	48.5	52.3	58.8	65.7	74.6	74.9	70.0	62.3	52.8	46.1
At Confluence												
10	46.5	46.5	49.0	54.3	60.4	65.2	69.3	68.8	65.0	59.4	53.7	46.6
30	46.4	46.3	48.7	54.1	60.3	65.2	69.2	68.5	64.9	59.3	53.6	46.5
50	46.2	46.1	48.5	53.7	58.6	64.6	69.0	68.4	64.8	59.2	53.6	46.4
70	45.8	45.8	48.3	53.3	57.8	64.0	68.8	68.3	64.7	59.1	53.4	46.2
90	45.6	45.7	48.1	52.9	57.5	61.5	68.3	68.2	64.6	58.9	51.8	45.7
Above Coleman Powerhouse												
10	47.2	47.2	49.7	55.8	62.9	68.6	73.6	73.0	68.5	62.0	55.4	47.4
30	47.0	46.9	49.4	55.5	62.8	68.6	73.5	72.8	68.3	61.8	55.3	47.2
50	46.7	46.7	49.0	54.8	60.4	67.8	73.2	72.7	68.2	61.7	55.2	47.0
70	46.2	46.2	48.8	54.3	59.2	66.8	73.0	72.5	68.2	61.7	55.1	46.7
90	45.9	46.0	48.4	53.6	58.7	63.4	72.5	72.4	68.0	61.5	52.7	46.0

Table M-8. Temperature Results for No Dam Removal Alternative

Range of Flow (%)	Temperature (ºF)											
	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec
At North Fork Battle Creek Feeder Assumed												
	45.0	45.0	47.5	52.5	55.0	56.0	57.5	56.0	55.0	52.5	50.0	45.0
At Eagle Canyon Dam												
10	45.2	45.2	47.7	52.9	55.7	56.9	58.6	57.2	55.9	53.2	50.4	45.2
30	45.2	45.2	47.7	52.9	55.7	56.9	58.6	57.1	55.9	53.2	50.4	45.2
50	45.1	45.1	47.6	52.8	55.4	56.9	58.6	57.1	55.8	53.1	50.4	45.2
70	45.1	45.1	47.6	52.7	55.3	56.7	58.6	57.1	55.8	53.1	50.4	45.1
90	45.1	45.1	47.6	52.7	55.3	56.4	58.6	57.1	55.8	53.1	50.2	45.1
At Wildcat Diversion Dam												
10	45.6	45.6	48.1	53.7	57.3	59.1	61.3	59.9	58.1	54.9	51.5	45.6
30	45.6	45.6	48.1	53.7	57.3	59.1	61.3	59.8	58.0	54.8	51.5	45.6
50	45.5	45.4	47.9	53.4	56.4	59.1	61.3	59.8	58.0	54.7	51.5	45.6
70	45.3	45.3	47.8	53.2	56.0	58.4	61.3	59.8	58.0	54.7	51.4	45.5
90	45.2	45.2	47.7	53.0	55.9	57.4	61.3	59.8	57.9	54.7	50.7	45.2
North Fork Battle Creek at Confluence												
10	46.0	46.0	48.5	54.5	58.7	60.9	63.7	62.3	60.0	56.3	52.4	46.0
30	46.0	46.0	48.5	54.5	58.7	60.9	63.7	62.2	59.9	56.2	52.4	46.0
50	45.8	45.7	48.1	54.0	57.3	60.9	63.7	62.2	59.9	56.1	52.4	46.0
70	45.5	45.5	48.0	53.7	56.7	60.0	63.6	62.2	59.8	56.1	52.3	45.8
90	45.4	45.4	47.8	53.3	56.5	58.3	63.6	62.1	59.8	56.1	51.1	45.4
Above South Diversion Dam Assumed												
	45.0	45.0	47.5	50.0	55.0	60.0	62.5	62.5	60.0	55.0	50.0	45.0
Above South Powerhouse												
10	45.4	45.4	47.9	50.9	56.6	62.1	65.2	65.2	62.1	56.6	51.1	45.4
30	45.4	45.4	47.9	50.9	56.6	62.1	65.2	65.2	62.1	56.6	51.1	45.4
50	45.4	45.4	47.8	50.8	56.3	62.1	65.2	65.2	62.1	56.6	51.1	45.4
70	45.3	45.3	47.8	50.6	55.9	62.1	65.2	65.2	62.1	56.6	51.1	45.4
90	45.2	45.2	47.7	50.5	55.8	61.2	65.2	65.2	62.1	56.6	50.6	45.2
At Inskip Diversion Dam												
10	45.6	45.6	48.0	52.1	56.2	59.4	61.7	60.9	58.8	54.9	50.9	45.6
30	45.5	45.5	48.0	52.1	56.2	59.4	61.7	61.0	58.9	54.9	50.9	45.6
50	45.5	45.5	47.9	52.0	56.1	59.4	61.7	61.0	59.0	55.0	50.9	45.5
70	45.4	45.4	47.9	51.8	56.0	59.5	61.7	61.0	59.0	55.0	50.9	45.5
90	45.3	45.4	47.8	51.5	56.0	59.6	61.7	61.0	59.0	54.9	50.7	45.4

Range of Flow (%)	Temperature (ºF)											
	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Above Inskip Powerhouse												
10	46.6	46.6	49.1	54.2	59.9	64.4	67.9	67.1	63.8	58.6	53.4	46.7
30	46.6	46.3	48.7	54.2	59.9	64.4	67.9	67.2	63.9	58.7	53.4	46.6
50	46.2	46.1	48.5	53.4	58.2	64.0	67.9	67.2	63.9	58.7	53.4	46.6
70	45.9	45.9	48.4	53.0	57.8	62.6	67.9	67.2	64.0	58.7	53.4	46.2
90	45.8	45.8	48.2	52.4	57.5	61.9	68.0	67.2	64.0	58.7	51.9	45.8
At Coleman Diversion Dam												
10	45.1	45.1	47.5	52.3	56.8	60.1	62.4	61.2	58.8	54.5	50.6	44.7
30	45.3	45.4	47.9	52.7	57.0	60.2	62.7	61.6	59.1	54.9	50.8	45.1
50	45.4	45.4	47.9	52.7	57.1	60.6	63.0	61.8	59.2	55.1	51.1	45.4
70	45.4	45.4	47.9	52.5	57.0	60.7	63.3	62.1	59.4	55.3	51.2	45.4
90	45.4	45.4	47.9	52.2	57.0	60.8	63.4	62.2	59.6	55.5	51.2	45.4
South Fork Battle Creek at Confluence												
10	46.1	46.1	48.5	54.3	60.8	65.4	69.0	67.8	62.9	57.5	52.6	45.7
30	46.4	46.4	48.9	54.8	61.0	65.5	69.2	68.2	63.1	57.9	52.8	46.1
50	46.5	46.5	48.8	54.7	60.8	65.9	69.6	68.4	63.3	58.2	53.1	46.4
70	46.1	46.1	48.6	54.2	59.4	66.0	69.9	68.6	63.4	58.3	53.3	46.5
90	45.9	46.0	48.3	53.3	59.0	64.1	70.0	68.8	63.6	58.5	52.8	46.0
At Confluence												
10	46.0	46.0	48.5	54.4	59.6	62.8	65.9	64.6	61.6	57.0	52.5	45.9
30	46.2	46.2	48.6	54.6	59.6	62.8	66.0	64.7	61.7	57.1	52.6	46.0
50	46.0	45.9	48.3	54.2	58.2	62.9	66.1	64.8	61.7	57.2	52.8	46.2
70	45.7	45.7	48.2	53.8	57.5	61.9	66.2	64.9	61.8	57.3	52.8	46.0
90	45.6	45.6	48.0	53.3	57.3	60.0	66.2	64.9	61.9	57.4	51.6	45.6
Above Coleman Powerhouse												
10	46.8	46.8	49.3	56.0	62.5	66.7	70.9	69.6	65.1	59.6	54.3	46.7
30	46.9	47.0	49.4	56.2	62.6	66.8	71.0	69.7	65.2	59.8	54.4	46.8
50	46.7	46.6	48.9	55.6	60.3	66.9	71.1	69.7	65.3	59.9	54.5	47.0
70	46.1	46.1	48.6	54.9	59.1	65.4	71.1	69.8	65.3	59.9	54.5	46.7
90	45.9	45.9	48.3	54.1	58.6	62.1	71.2	69.9	65.4	60.0	52.6	46.0
At Coleman National Fish Hatchery												
10	46.2	46.2	48.2	52.8	57.2	60.4	62.2	60.9	58.3	54.6	51.3	46.1
30	46.3	46.3	48.5	53.2	57.5	60.6	62.8	61.7	58.9	55.2	51.5	46.2
50	46.3	46.3	48.5	53.2	57.7	61.2	63.4	62.0	59.2	55.6	51.7	46.3
70	46.4	46.4	48.5	53.0	57.5	61.3	63.9	62.5	59.5	55.8	51.9	46.3
90	46.4	46.4	48.5	52.7	57.3	61.2	64.1	62.7	59.9	56.0	51.9	46.4

Table M-9. Temperature Results for Six Dam Removal Alternative

Range of Flow (%)	Temperature (ºF)											
	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec
At North Fork Battle Creek Feeder Assumed												
	45.0	45.0	47.5	52.5	55.0	56.0	57.5	56.0	55.0	52.5	50.0	45.0
At Eagle Canyon Dam												
10	45.2	45.2	47.7	52.8	55.5	56.8	58.6	57.2	55.9	53.2	50.4	45.2
30	45.2	45.1	47.6	52.8	55.5	56.7	58.5	57.1	55.9	53.2	50.4	45.2
50	45.1	45.1	47.6	52.8	55.4	56.7	58.4	57.0	55.8	53.1	50.4	45.1
70	45.1	45.1	47.6	52.7	55.3	56.7	58.4	56.9	55.8	53.1	50.4	45.1
90	45.1	45.1	47.6	52.7	55.3	56.4	58.4	56.9	55.7	53.0	50.2	45.1
At Wildcat Diversion Dam												
10	45.5	45.5	48.0	53.5	56.5	58.1	60.6	59.4	57.6	54.5	51.2	45.6
30	45.4	45.4	47.9	53.3	56.4	58.0	60.4	59.1	57.4	54.3	51.1	45.5
50	45.4	45.4	47.8	53.3	56.2	57.9	60.1	58.9	57.3	54.1	51.0	45.4
70	45.3	45.3	47.8	53.1	55.9	57.8	59.9	58.7	57.2	54.0	50.9	45.4
90	45.2	45.2	47.7	53.0	55.8	57.2	59.9	58.5	57.0	53.9	50.6	45.2
North Fork Battle Creek at Confluence												
10	45.8	45.8	48.3	54.1	57.4	59.4	62.5	61.4	59.2	55.7	51.8	45.9
30	45.7	45.6	48.1	53.8	57.3	59.3	62.2	60.9	58.9	55.3	51.7	45.8
50	45.6	45.6	48.0	53.7	56.9	59.0	61.7	60.7	58.7	55.1	51.6	45.7
70	45.4	45.4	48.0	53.5	56.5	58.9	61.4	60.3	58.5	54.9	51.5	45.6
90	45.3	45.4	47.8	53.3	56.3	58.0	61.2	60.0	58.2	54.8	51.0	45.4
Above South Diversion Dam Assumed												
	45.0	45.0	47.5	50.0	55.0	60.0	62.5	62.5	60.0	55.0	50.0	45.0
Above South Powerhouse												
10	45.3	45.3	47.8	50.7	56.0	61.5	64.7	65.0	61.9	56.4	50.8	45.4
30	45.3	45.3	47.8	50.5	55.9	61.4	64.5	64.7	61.7	56.2	50.7	45.3
50	45.2	45.2	47.7	50.5	55.7	61.1	64.3	64.5	61.6	56.1	50.6	45.3
70	45.2	45.2	47.7	50.4	55.6	61.0	64.0	64.3	61.5	56.0	50.6	45.2
90	45.2	45.2	47.7	50.4	55.6	60.9	63.9	64.2	61.4	55.9	50.4	45.2
At Inskip Diversion Dam												
10	45.3	45.3	47.8	50.7	56.0	61.5	64.7	65.0	61.9	56.4	50.8	45.4
30	45.3	45.3	47.8	50.5	55.9	61.4	64.5	64.7	61.7	56.2	50.7	45.3
50	45.2	45.2	47.7	50.5	55.7	61.1	64.3	64.5	61.6	56.1	50.6	45.3
70	45.2	45.2	47.7	50.4	55.6	61.0	64.0	64.3	61.5	56.0	50.6	45.2
90	45.2	45.2	47.7	50.4	55.6	60.9	63.9	64.2	61.4	55.9	50.4	45.2

Range of Flow (%)	Temperature (ºF)											
	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Above Inskip Powerhouse												
10	46.1	46.1	48.6	52.4	59.2	65.8	70.1	70.3	66.2	59.6	53.0	46.2
30	46.0	46.0	48.5	52.3	59.1	65.7	69.9	70.0	66.0	59.4	52.9	46.1
50	46.0	45.9	48.4	51.9	57.9	65.4	69.7	69.9	65.9	59.3	52.8	46.0
70	45.7	45.7	48.2	51.6	57.4	64.4	69.4	69.7	65.8	59.3	52.7	46.0
90	45.6	45.6	48.1	51.3	57.2	63.2	69.3	69.6	65.7	59.1	51.6	45.6
At Coleman Diversion Dam												
10	46.1	46.1	48.6	52.4	59.2	65.8	70.1	70.3	66.2	59.6	53.0	46.2
30	46.0	46.0	48.5	52.3	59.1	65.7	69.9	70.0	66.0	59.4	52.9	46.1
50	46.0	45.9	48.4	51.9	57.9	65.4	69.7	69.9	65.9	59.3	52.8	46.0
70	45.7	45.7	48.2	51.6	57.4	64.4	69.4	69.7	65.8	59.3	52.7	46.0
90	45.6	45.6	48.1	51.3	57.2	63.2	69.3	69.6	65.7	59.1	51.6	45.6
South Fork Battle Creek at Confluence												
10	46.8	46.8	49.3	54.2	62.4	70.0	75.4	75.7	70.5	62.8	55.1	47.1
30	46.8	46.7	49.2	54.0	62.3	70.0	75.3	75.4	70.3	62.7	55.0	46.8
50	46.7	46.6	49.0	53.3	60.1	69.7	75.0	75.3	70.2	62.5	54.9	46.8
70	46.3	46.3	48.8	52.9	59.2	67.8	74.8	75.1	70.1	62.5	54.9	46.7
90	46.0	46.1	48.5	52.3	58.8	65.7	74.6	74.9	70.0	62.3	52.8	46.1
At Confluence												
10	46.3	46.3	48.8	54.1	59.0	63.1	67.8	67.8	64.0	58.7	53.1	46.5
30	46.1	46.1	48.5	53.9	58.8	62.7	67.1	66.7	63.4	58.1	52.8	46.3
50	46.0	45.9	48.4	53.6	58.0	62.0	66.1	66.2	63.0	57.6	52.6	46.1
70	45.7	45.8	48.3	53.3	57.5	62.1	65.3	65.4	62.6	57.3	52.4	46.0
90	45.6	45.6	48.1	52.9	57.2	60.8	65.0	64.8	62.0	56.9	51.6	45.6
Above Coleman Powerhouse												
10	46.9	46.9	49.4	55.4	61.0	65.9	71.7	71.8	67.2	61.1	54.6	47.2
30	46.7	46.6	49.1	55.0	60.8	65.5	70.9	70.5	66.5	60.4	54.3	46.9
50	46.5	46.4	48.9	54.6	59.6	64.6	69.6	70.0	66.0	59.7	53.9	46.7
70	46.1	46.1	48.7	54.1	58.8	64.4	68.7	68.9	65.5	59.4	53.7	46.5
90	45.9	46.0	48.3	53.6	58.4	62.5	68.3	68.2	64.8	58.9	52.5	46.0
At Coleman National Fish Hatchery												
10	47.2	47.2	49.2	54.0	58.0	61.1	62.9	61.1	59.4	55.9	52.5	47.3
30	47.0	46.9	49.1	53.8	58.1	61.3	63.5	62.2	59.9	56.3	52.5	47.2
50	46.9	46.9	49.1	54.0	58.1	61.7	64.0	62.5	60.2	56.5	52.5	47.0
70	47.0	47.0	49.1	53.9	57.9	61.5	64.5	63.1	60.5	56.6	52.5	46.9
90	47.1	47.1	49.1	53.7	57.8	61.1	64.6	63.4	60.8	56.8	52.4	47.1

Table M-10. Temperature Results for the Three Dam Removal Alternative

Range of Flow (%)	Temperature (ºF)											
	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec
At North Fork Battle Creek Feeder Assumed												
	45.0	45.0	47.5	52.5	55.0	56.0	57.5	56.0	55.0	52.5	50.0	45.0
At Eagle Canyon Dam												
10	45.2	45.2	47.7	52.9	55.7	56.9	58.6	57.2	55.9	53.2	50.4	45.2
30	45.2	45.2	47.7	52.9	55.7	56.9	58.6	57.1	55.9	53.2	50.4	45.2
50	45.1	45.1	47.6	52.8	55.4	56.9	58.6	57.1	55.8	53.1	50.4	45.2
70	45.1	45.1	47.6	52.7	55.3	56.7	58.6	57.1	55.8	53.1	50.4	45.1
90	45.1	45.1	47.6	52.7	55.3	56.4	58.6	57.1	55.8	53.1	50.2	45.1
At Wildcat Diversion Dam												
10	45.5	45.5	48.0	53.5	56.7	58.4	60.6	59.4	57.6	54.5	51.2	45.6
30	45.5	45.5	48.0	53.5	56.7	58.3	60.6	59.1	57.4	54.3	51.1	45.5
50	45.4	45.4	47.8	53.3	56.2	58.2	60.4	59.1	57.3	54.1	51.0	45.5
70	45.3	45.3	47.8	53.1	55.9	57.9	60.3	59.0	57.2	54.1	51.0	45.4
90	45.2	45.2	47.7	53.0	55.8	57.2	60.2	58.9	57.1	54.0	50.6	45.2
North Fork Battle Creek at Confluence												
10	45.8	45.8	48.3	54.2	57.7	59.7	62.5	61.4	59.2	55.7	51.8	45.9
30	45.8	45.8	48.2	54.0	57.6	59.7	62.4	61.0	58.9	55.3	51.7	45.8
50	45.6	45.6	48.0	53.7	56.9	59.4	62.1	60.9	58.7	55.1	51.6	45.8
70	45.4	45.4	48.0	53.5	56.5	58.9	61.9	60.7	58.5	55.0	51.6	45.6
90	45.3	45.4	47.8	53.3	56.3	58.0	61.7	60.6	58.4	54.9	51.0	45.4
Above South Diversion Dam Assumed												
	45.0	45.0	47.5	50.0	55.0	60.0	62.5	62.5	60.0	55.0	50.0	45.0
Above South Powerhouse												
10	45.4	45.4	47.9	50.9	56.6	62.1	65.2	65.2	62.1	56.6	51.1	45.4
30	45.4	45.4	47.9	50.9	56.6	62.1	65.2	65.2	62.1	56.6	51.1	45.4
50	45.4	45.4	47.8	50.8	56.3	62.1	65.2	65.2	62.1	56.6	51.1	45.4
70	45.3	45.3	47.8	50.6	55.9	62.1	65.2	65.2	62.1	56.6	51.1	45.4
90	45.2	45.2	47.7	50.5	55.8	61.2	65.2	65.2	62.1	56.6	50.6	45.2
At Inskip Diversion Dam												
10	45.4	45.4	47.9	50.9	56.6	62.1	65.2	65.2	62.1	56.6	51.1	45.4
30	45.4	45.4	47.9	50.9	56.6	62.1	65.2	65.2	62.1	56.6	51.1	45.4
50	45.4	45.4	47.8	50.9	56.3	62.1	65.2	65.2	62.1	56.6	51.1	45.4
70	45.3	45.3	47.8	50.7	55.9	62.1	65.2	65.2	62.1	56.6	51.1	45.4
90	45.2	45.2	47.7	50.5	55.8	61.2	65.2	65.2	62.1	56.6	50.6	45.2

Range of Flow (%)	Temperature (ºF)											
	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Above Inskip Powerhouse												
10	46.5	46.5	49.0	53.0	60.3	67.1	71.4	71.4	67.1	60.3	53.6	46.5
30	46.5	46.3	48.7	52.9	60.3	67.1	71.4	71.4	67.1	60.3	53.6	46.5
50	46.2	46.1	48.5	52.3	58.4	66.7	71.4	71.4	67.1	60.3	53.6	46.5
70	45.8	45.8	48.3	51.9	57.7	65.4	71.4	71.4	67.1	60.3	53.6	46.2
90	45.6	45.7	48.1	51.4	57.4	63.6	71.4	71.4	67.1	60.3	51.8	45.7
At Coleman Diversion Dam												
10	46.5	46.5	49.0	53.0	60.3	67.1	71.4	71.4	67.1	60.3	53.6	46.5
30	46.5	46.3	48.7	52.9	60.3	67.1	71.4	71.4	67.1	60.3	53.6	46.5
50	46.2	46.1	48.5	52.3	58.4	66.7	71.4	71.4	67.1	60.3	53.6	46.5
70	45.8	45.8	48.3	51.9	57.7	65.4	71.4	71.4	67.1	60.3	53.6	46.2
90	45.6	45.7	48.1	51.4	57.4	63.6	71.4	71.4	67.1	60.3	51.8	45.7
South Fork Battle Creek at Confluence												
10	47.7	47.7	50.2	55.4	64.6	72.8	78.5	78.6	72.8	64.6	56.4	47.7
30	47.7	47.2	49.6	55.2	64.6	72.8	78.5	78.5	72.8	64.6	56.4	47.7
50	47.0	46.8	49.2	53.8	60.7	71.9	78.5	78.5	72.8	64.6	56.4	47.7
70	46.4	46.4	48.9	53.1	59.6	68.9	78.5	78.5	72.8	64.6	56.4	47.0
90	46.1	46.2	48.5	52.4	59.1	66.1	78.5	78.5	72.8	64.6	53.0	46.2
At Confluence												
10	46.3	46.3	48.8	54.5	59.3	63.0	67.0	66.7	63.2	58.3	53.0	46.5
30	46.3	46.2	48.7	54.3	59.1	62.8	66.7	65.8	62.6	57.7	52.8	46.3
50	46.1	46.0	48.4	53.7	58.2	62.3	66.1	65.6	62.3	57.2	52.6	46.2
70	45.8	45.8	48.3	53.4	57.6	62.3	65.5	65.1	61.9	57.0	52.5	46.1
90	45.6	45.6	48.1	53.0	57.3	60.8	65.2	64.8	61.5	56.8	51.7	45.7
Above Coleman Powerhouse												
10	47.1	47.1	49.6	55.9	61.7	66.2	71.2	71.1	66.7	60.9	54.6	47.2
30	46.9	46.8	49.3	55.6	61.3	66.0	70.8	70.0	65.9	60.1	54.3	47.1
50	46.6	46.5	48.9	54.8	59.7	65.1	70.1	69.7	65.5	59.5	54.1	46.9
70	46.1	46.2	48.7	54.3	58.9	64.7	69.3	69.1	64.9	59.2	53.9	46.6
90	45.9	46.0	48.4	53.7	58.5	62.5	68.8	68.7	64.5	58.9	52.5	46.0
At Coleman National Fish Hatchery												
10	45.5	45.5	47.6	52.4	56.7	59.6	60.5	58.3	56.7	53.1	50.3	44.9
30	45.9	45.9	48.1	53.0	57.2	59.9	61.5	60.0	57.6	54.2	50.7	45.5
50	46.0	46.0	48.2	53.1	57.2	60.8	62.6	60.6	58.1	54.8	51.3	45.9
70	46.2	46.2	48.2	53.0	57.0	60.5	63.5	61.5	58.7	55.2	51.6	46.0
90	46.4	46.3	48.3	52.9	56.9	60.2	63.9	62.1	59.3	55.7	51.6	46.3

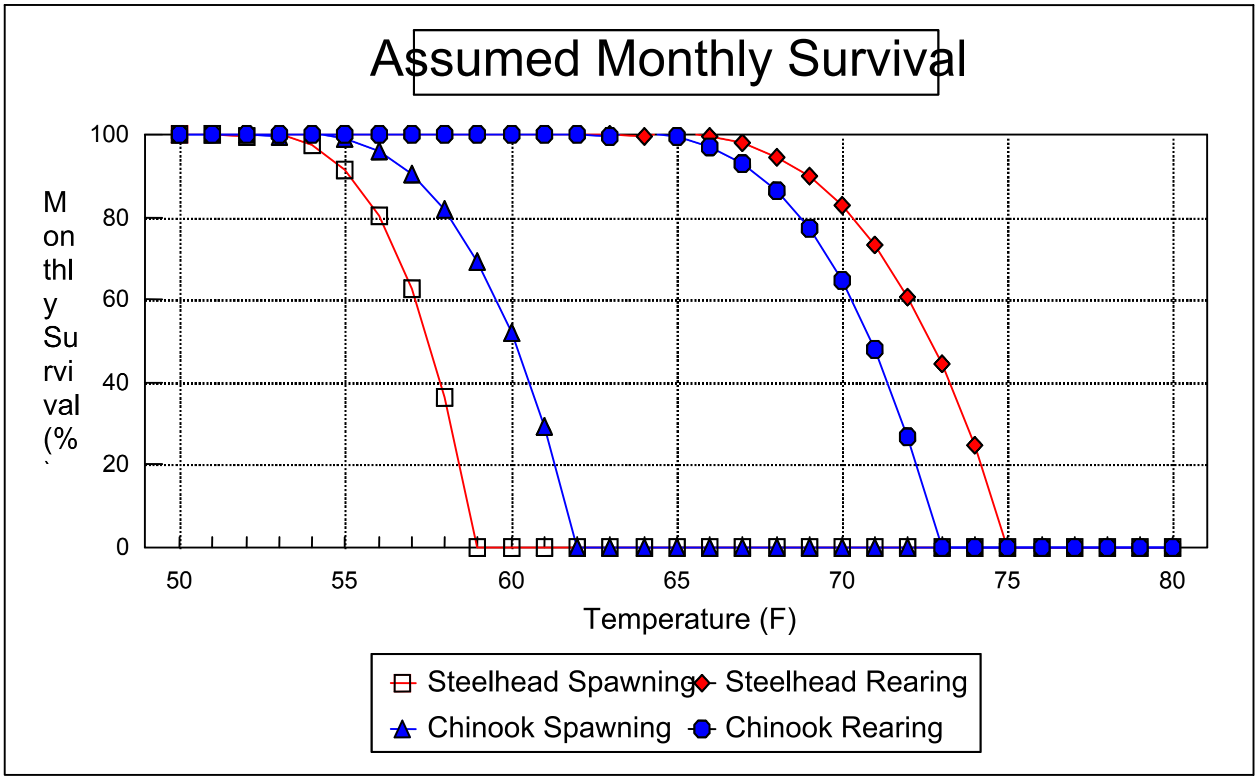


Figure M-1. Effects of Temperature on Monthly Survival of Steelhead and Chinook.

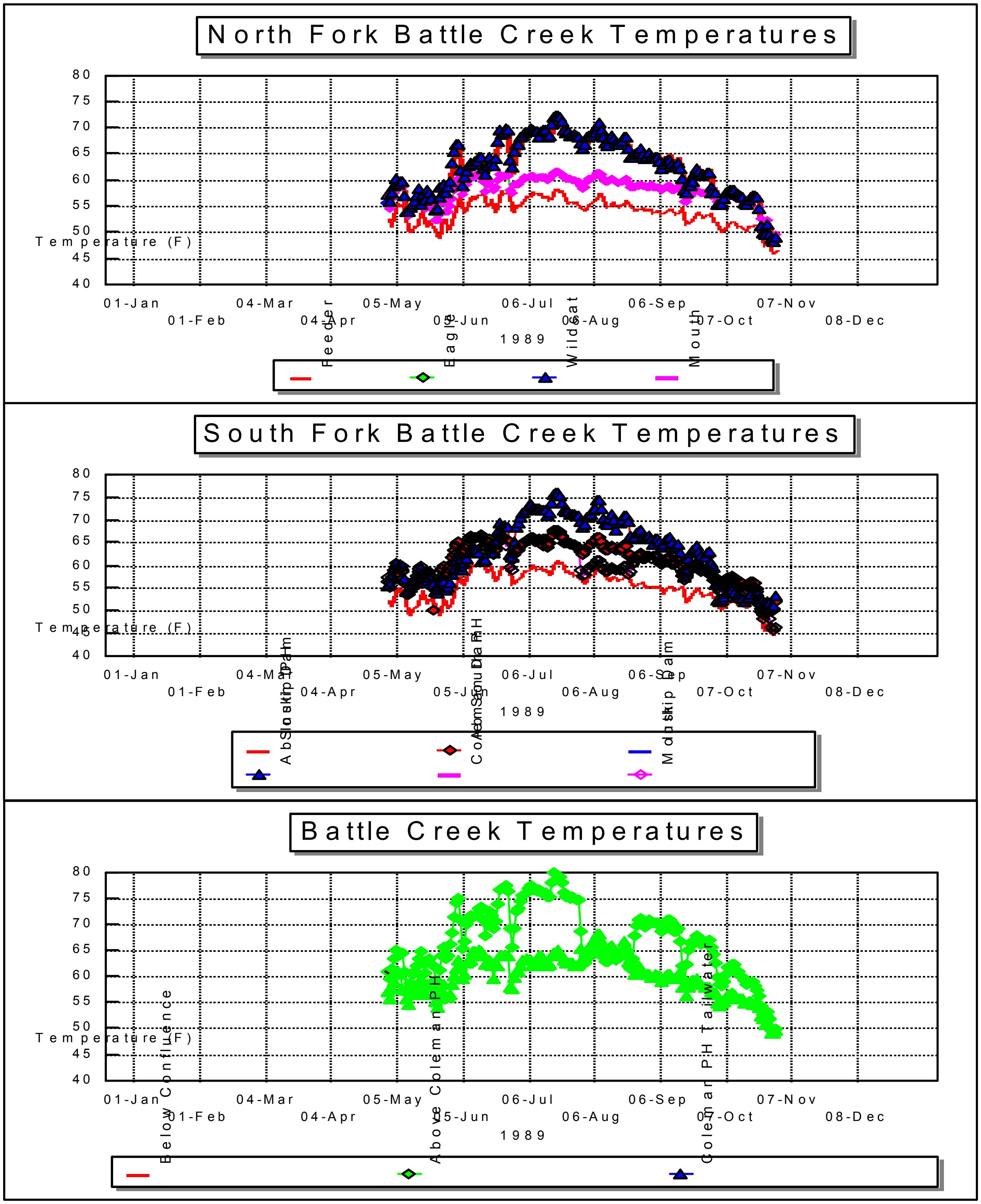


Figure M-2. Battle Creek Water Temperatures, 1989

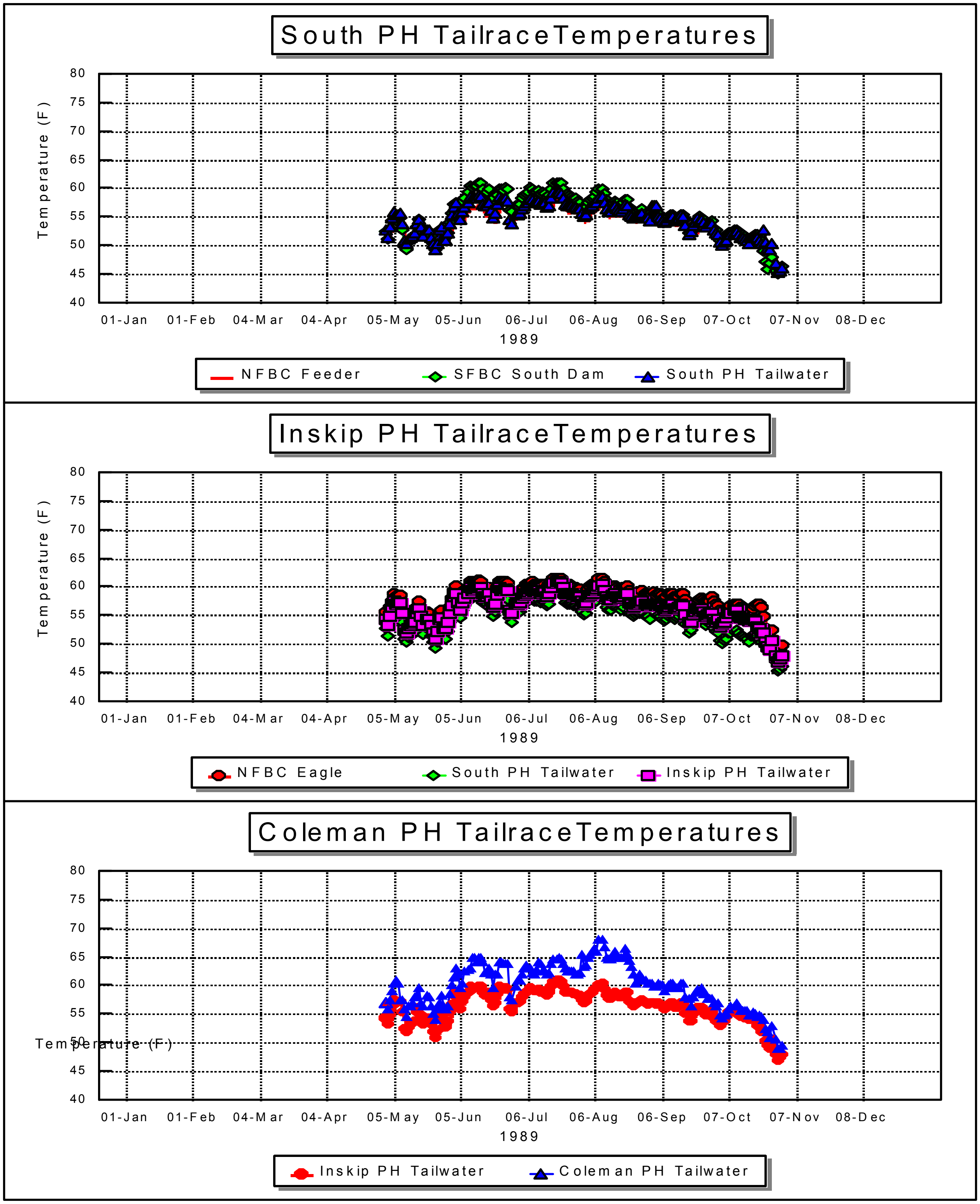


Figure M-3. Battle Creek Operational Water Temperatures, 1989.

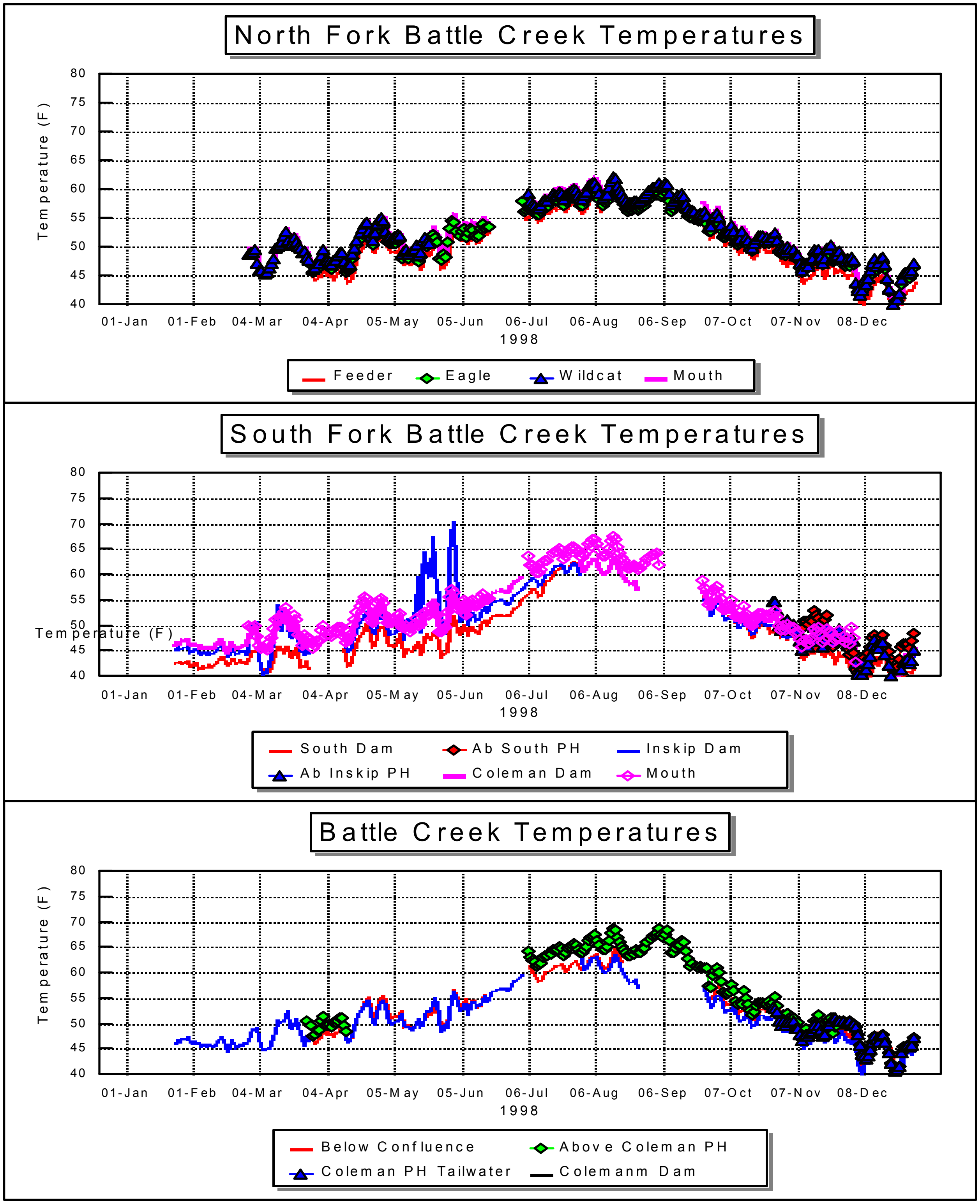


Figure M-4. Battle Creek Water Temperatures, 1998.

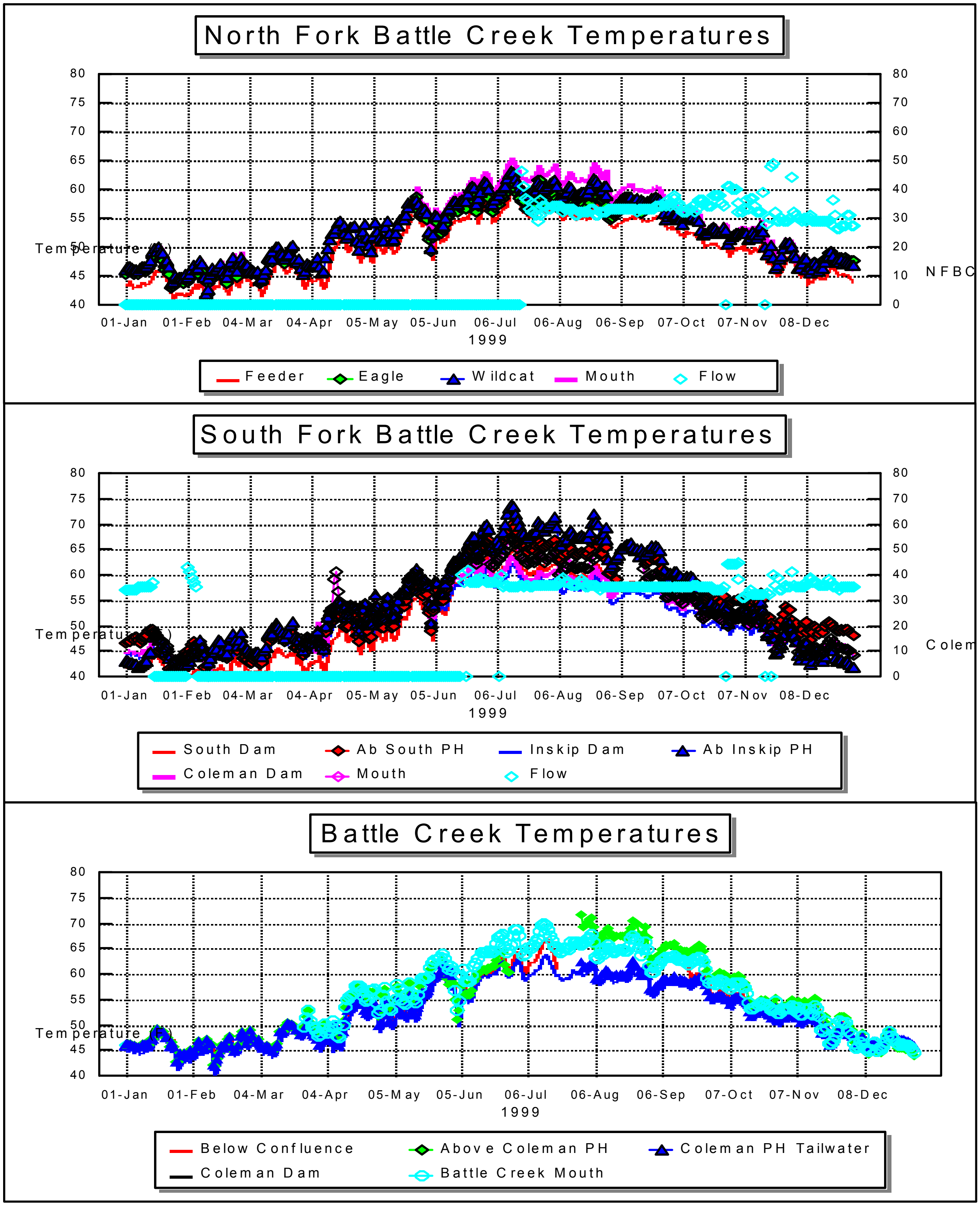


Figure M-5. Battle Creek Water Temperatures and Flows, 1999.

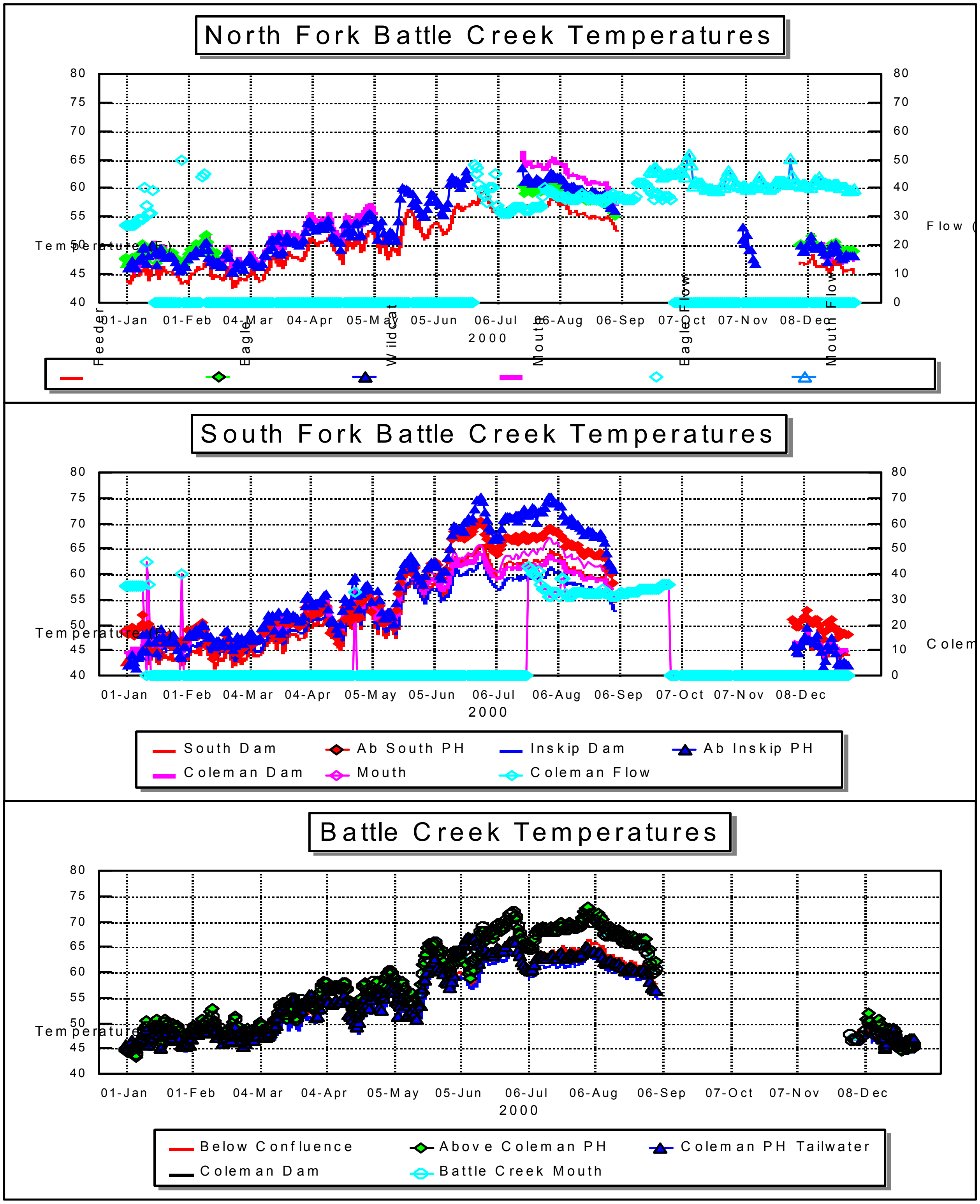


Figure M-6. Battle Creek Water Temperatures and Flows, 2000.

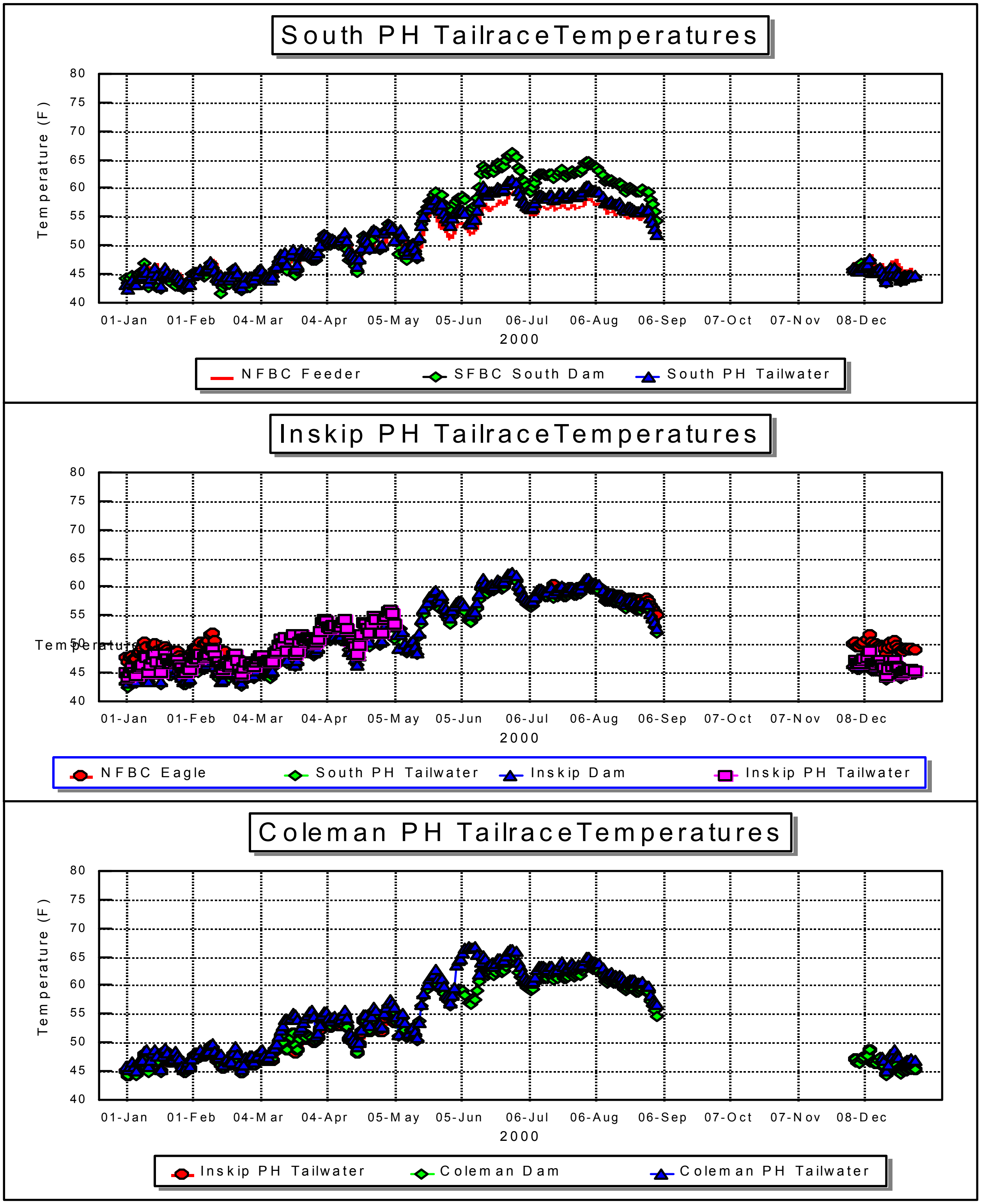


Figure M-7. Battle Creek Operational Water Temperatures, 2000.

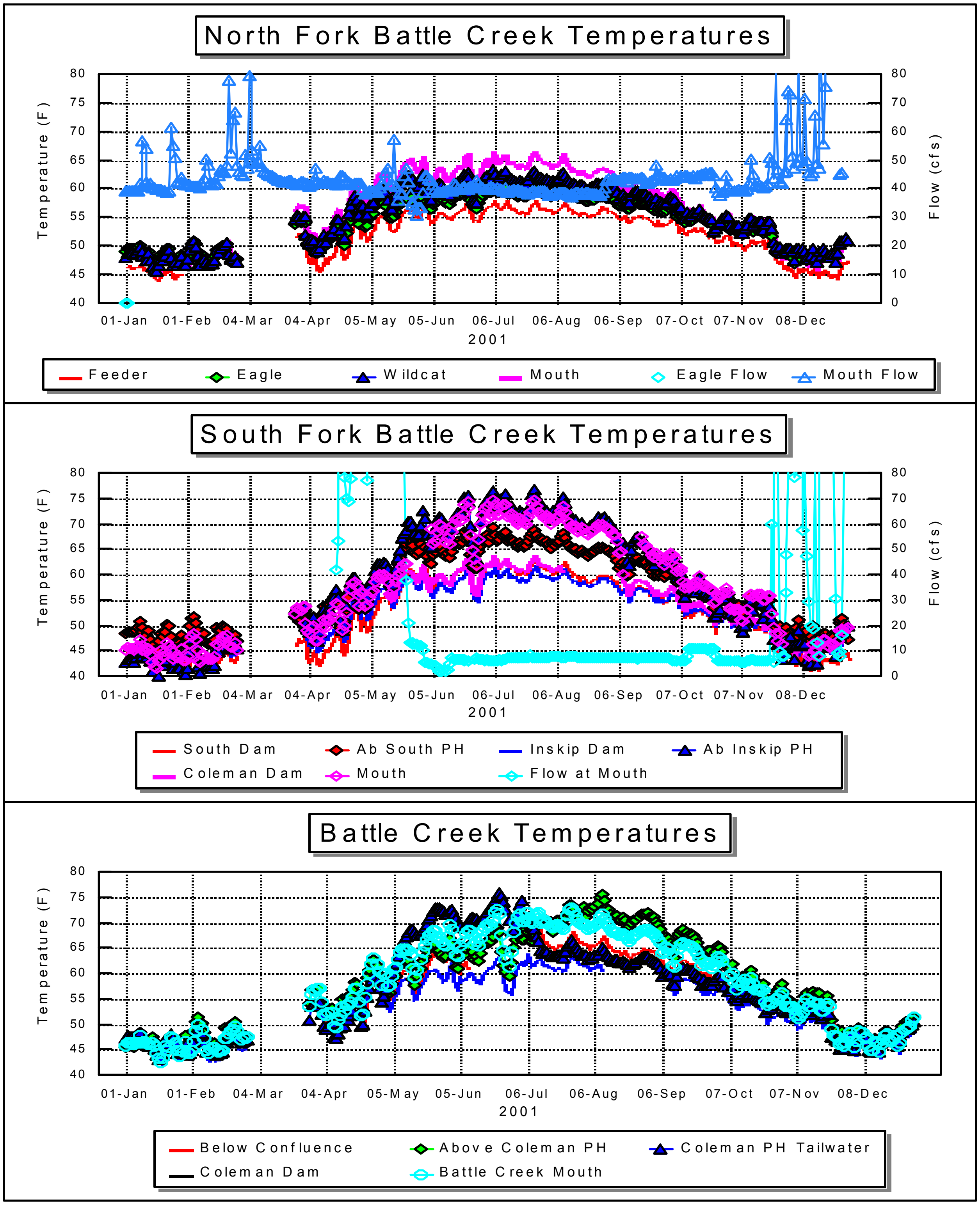


Figure M-8. Battle Creek Water Temperatures and Flows, 2001.

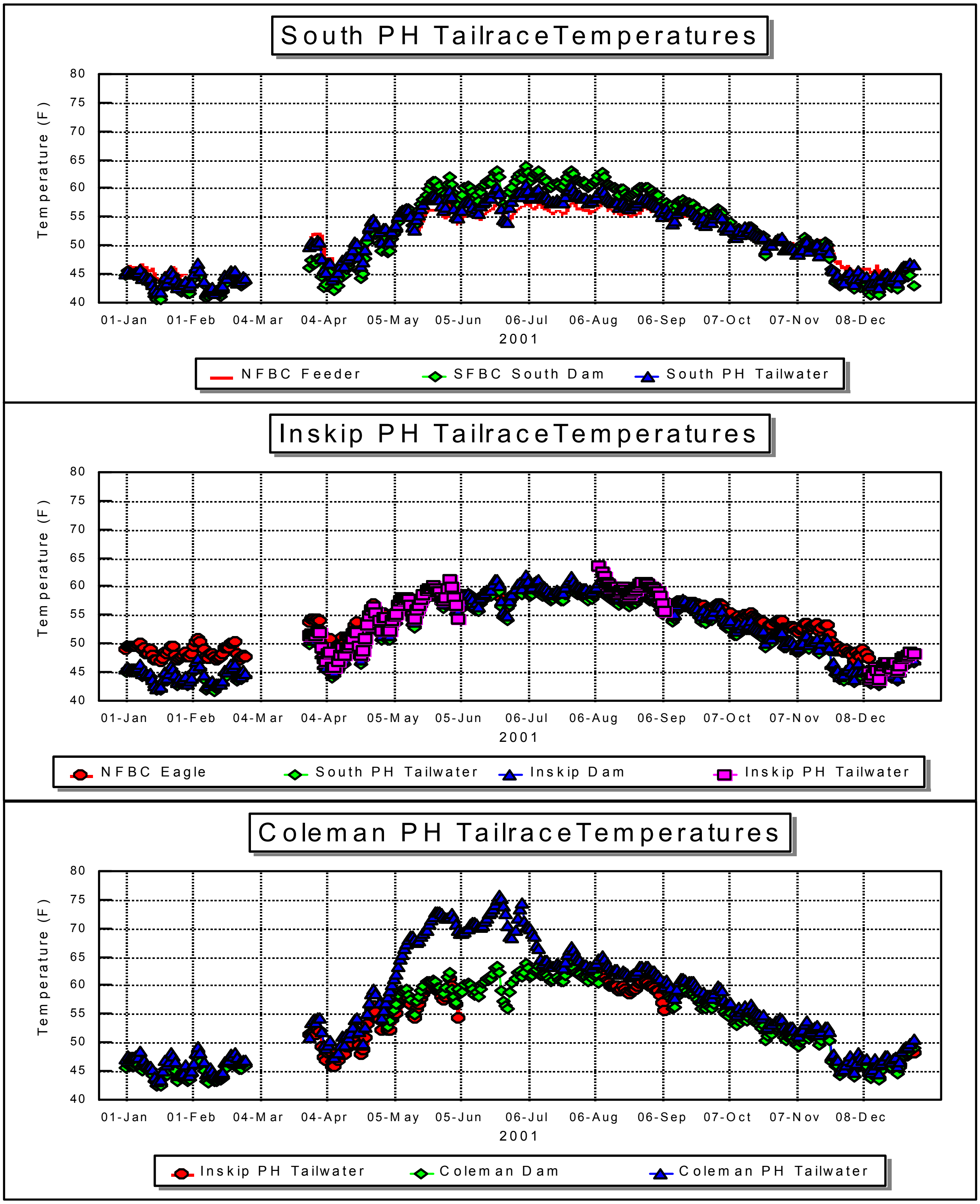
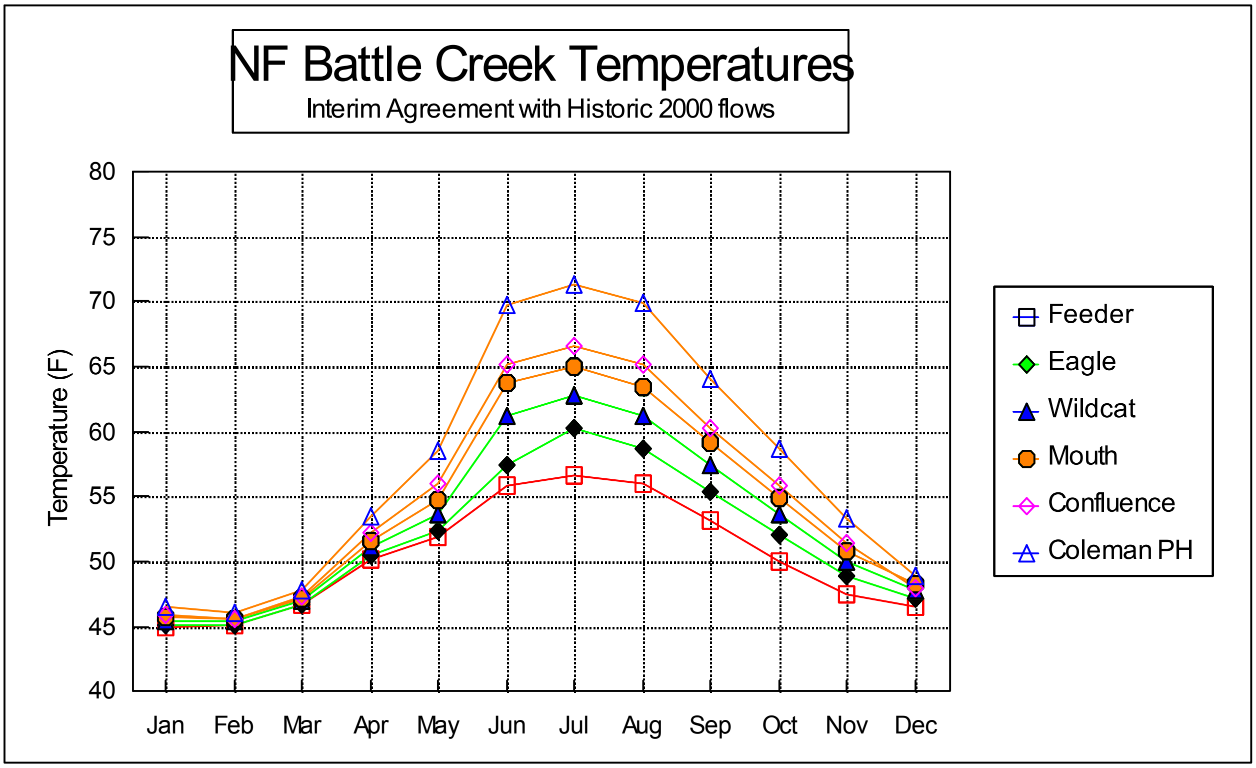


Figure M-9. Battle Creek Operational Water Temperatures, 2001.



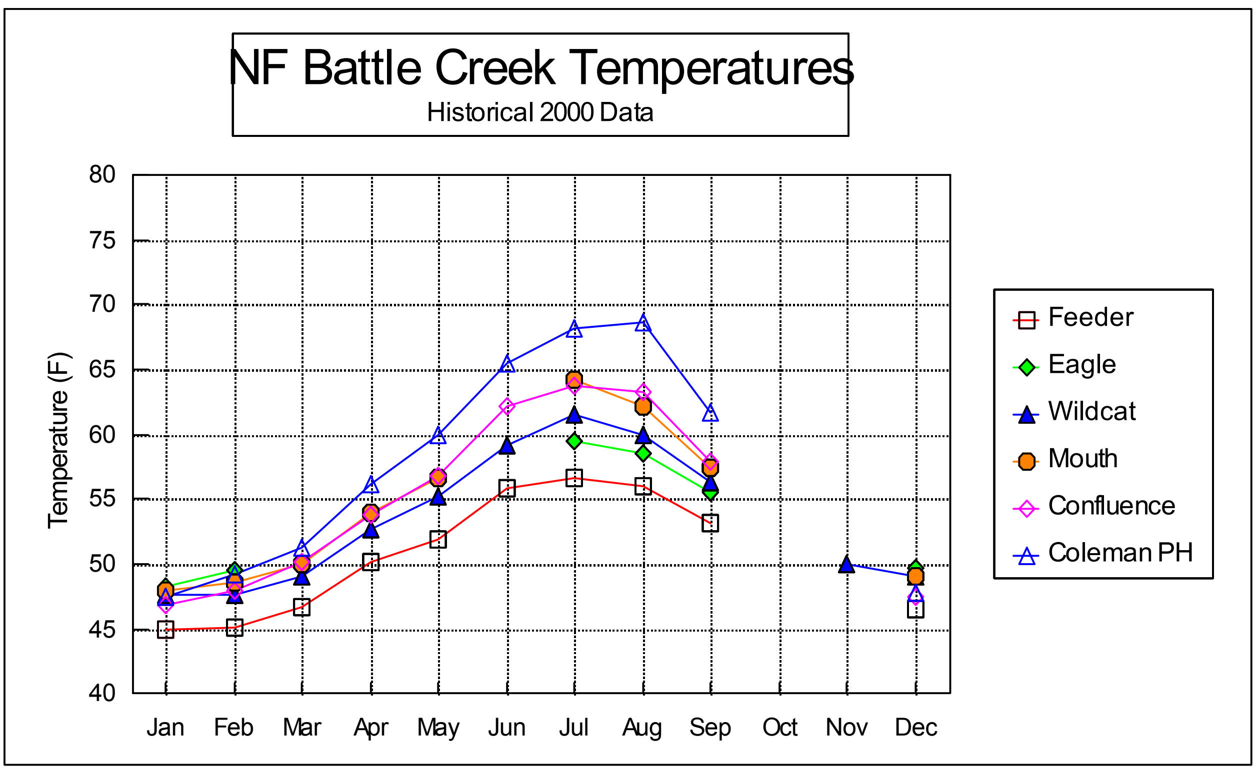


Figure M-10. North Fork Battle Creek Calibration for 2000.

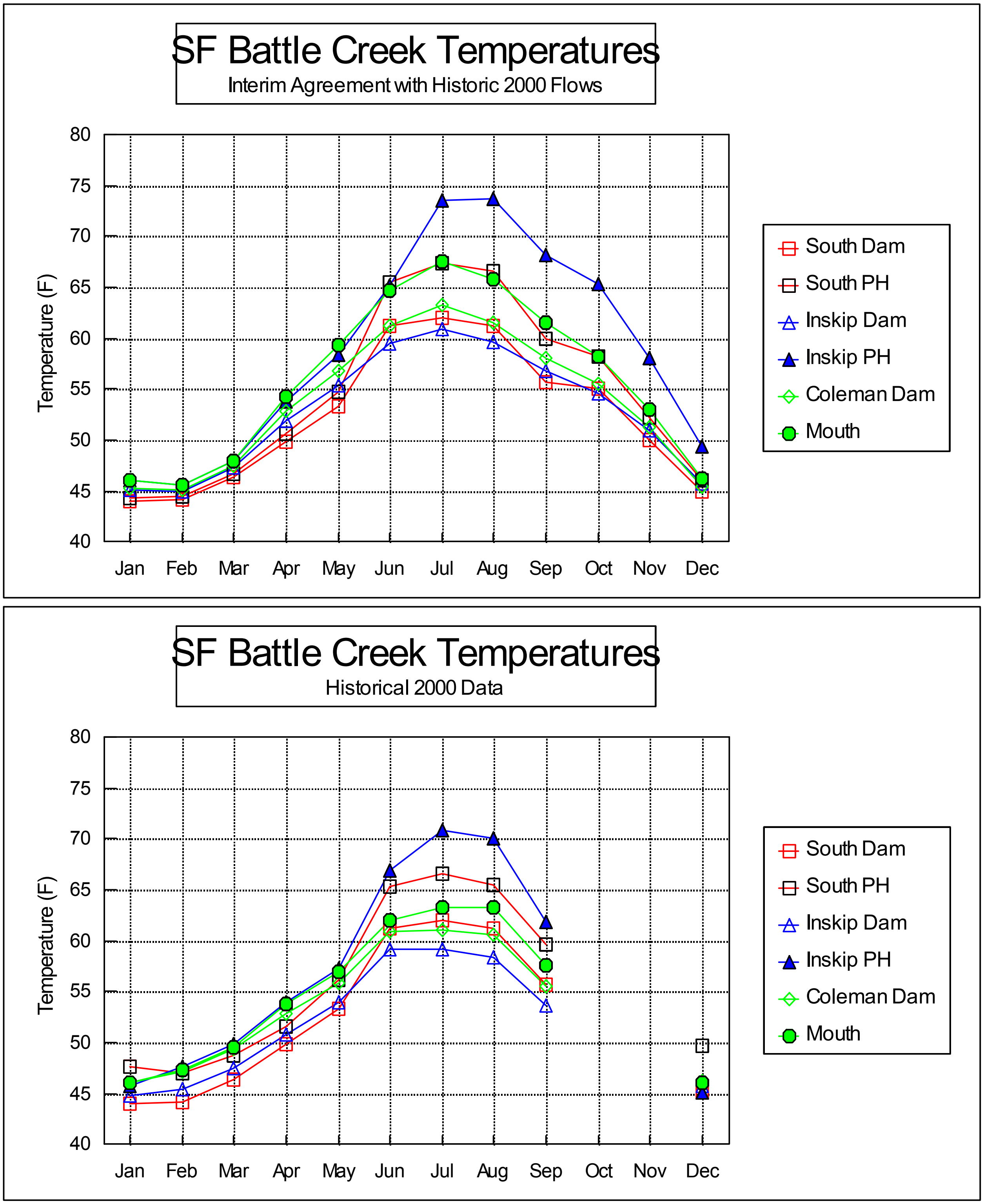
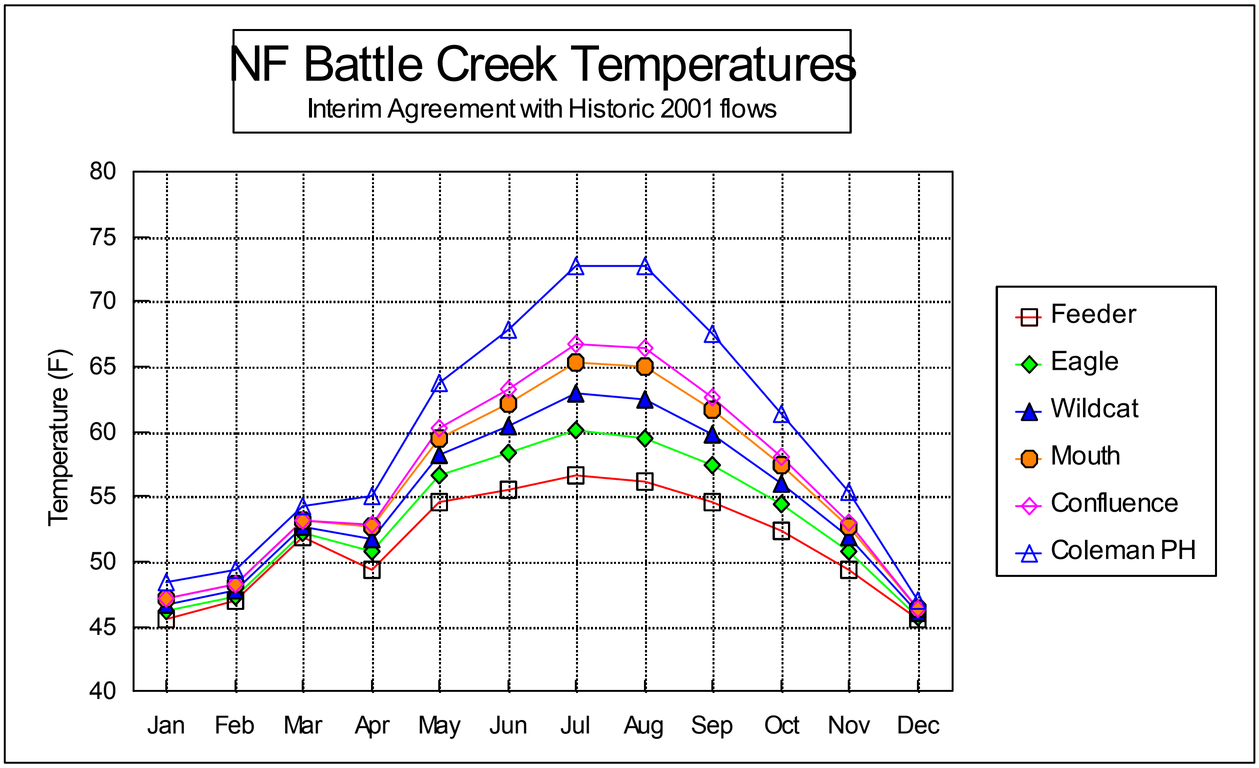


Figure M-11. South Fork Battle Creek Calibration for 2000.



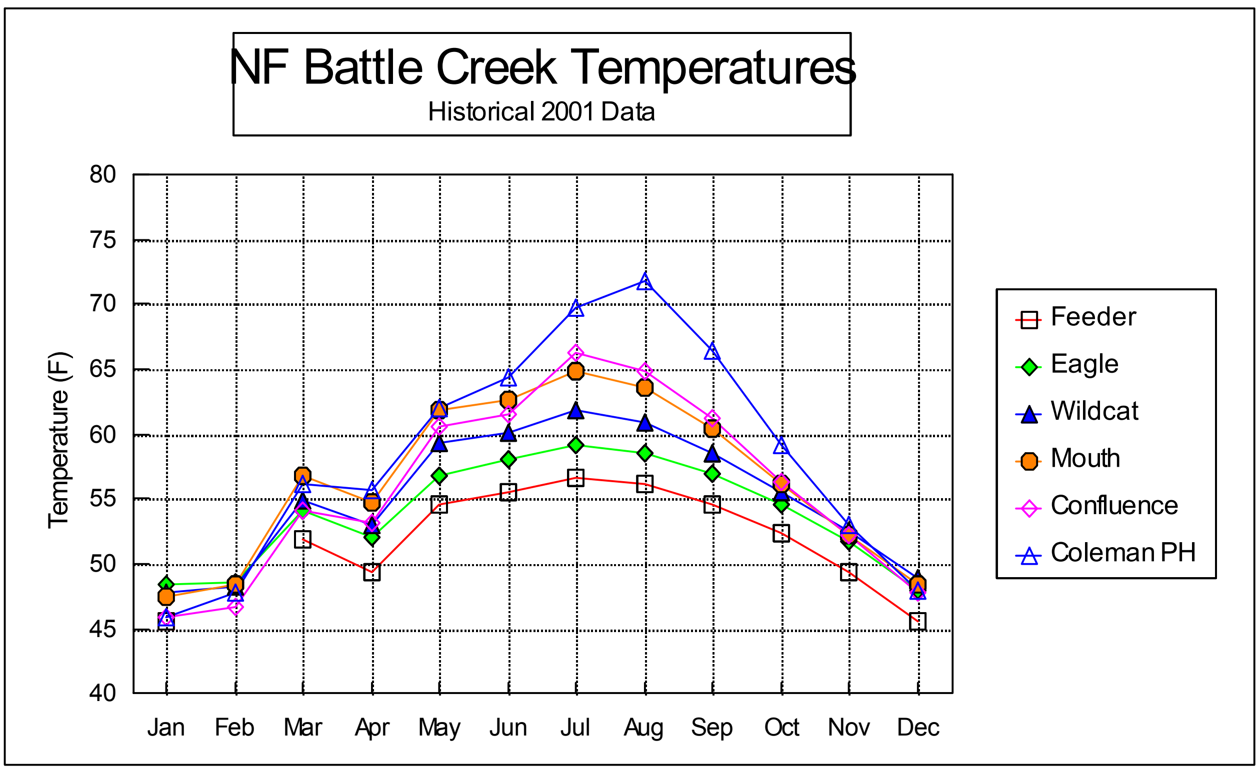
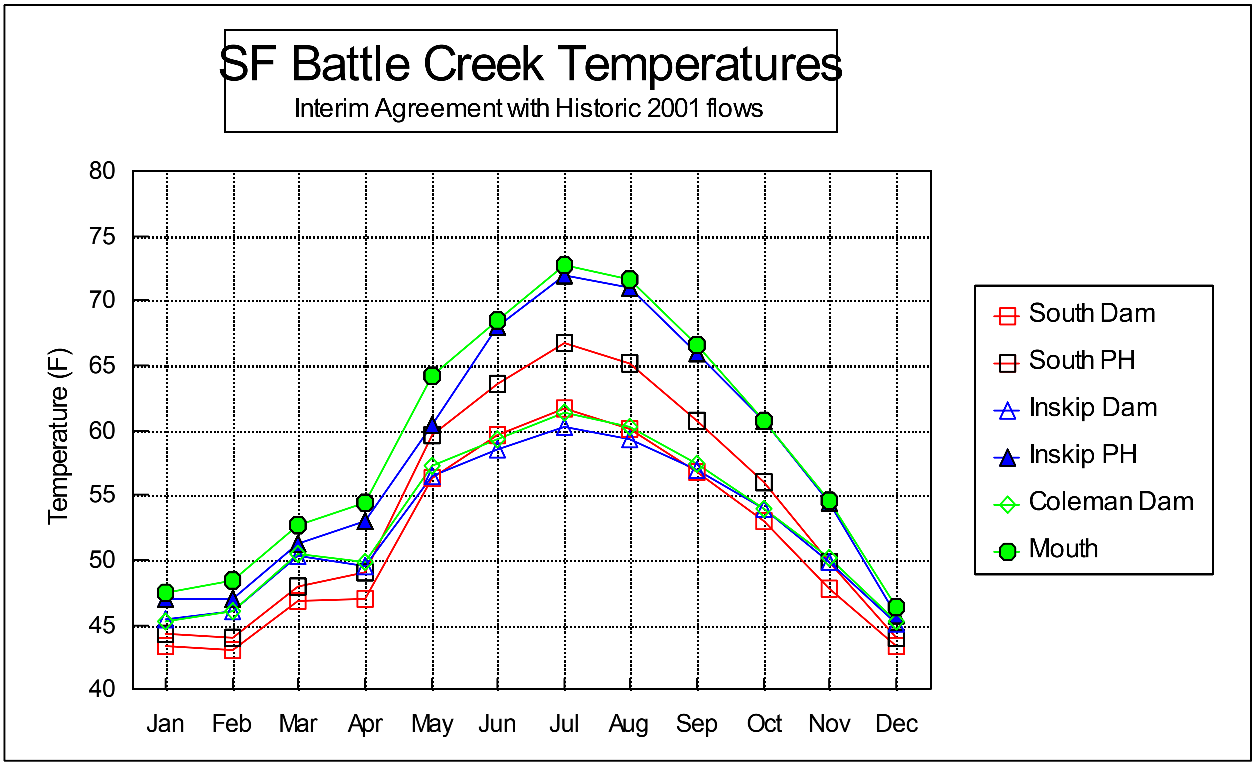


Figure M-12. North Fork Battle Creek Calibration for 2001.



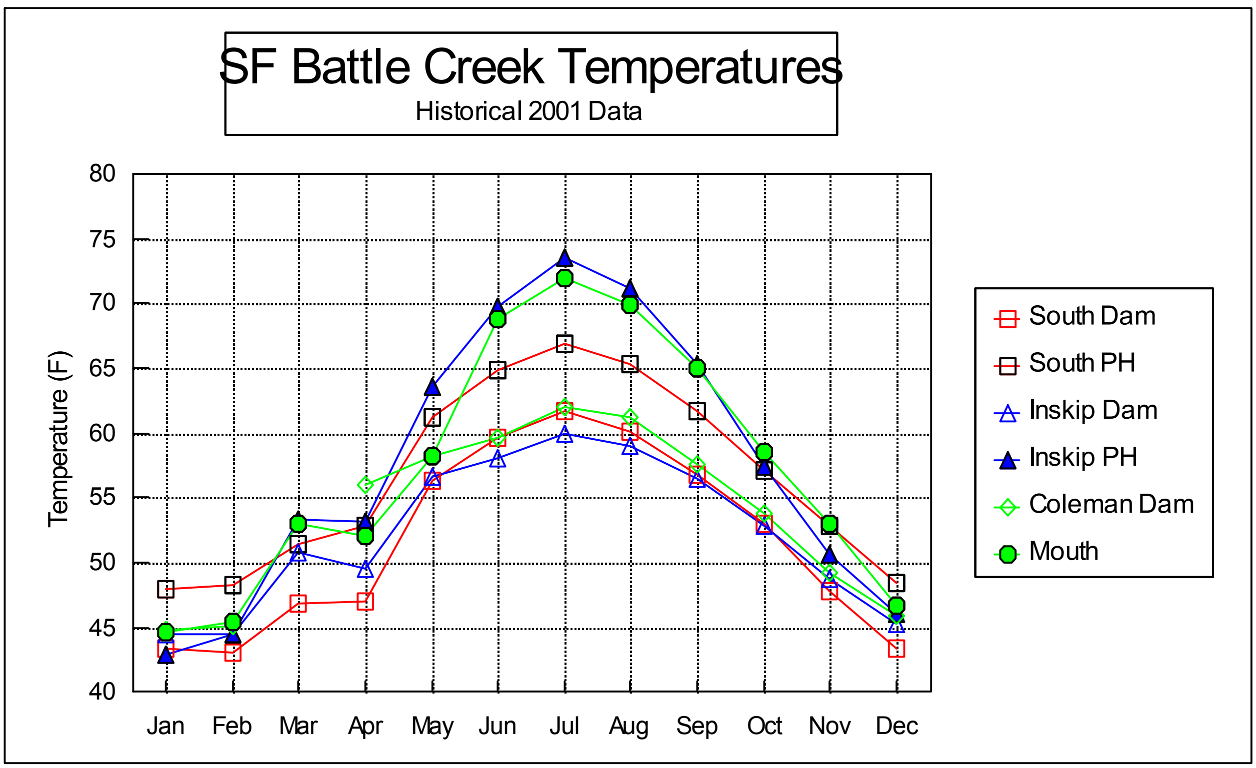


Figure M-13. South Fork Battle Creek Calibration for 2001.