Attachment 1

Water temperature Variation from Friant Dam to Sack Dam During the 2009 Fall Interim Flow Period

DRAFT
Appendix C – Water Quality Data

SAN JOAQUIN RIVER
RESTORATION PROGRAM

Draft
March 2010

1.0 Introduction

The following attachment includes a report provided by the U.S. Fish and Wildlife Service and the California Department of Fish and Game entitled, *Water temperature variation from Friant Dam to Sack Dam during the 2009 Fall Interim Flow Period*. This report details monitoring methodology and results from monitoring water temperatures in the San Joaquin River during the fall 2009 Interim Flows period.

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Water temperature variation from Friant Dam to Sack Dam during the 2009 Fall Interim Flow Period

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Introduction

Water temperature exerts a substantial influence on the abundance, development, growth and survival of fishes, including Chinook salmon (EPA 1999; Myreck and Cech 2004). Temperature is critical to the timing of life-history events, especially reproduction (Fry 1971). High temperatures result in physiological stress and increased metabolic demand on fishes, which may result in slower growth, susceptibility to disease, and lower survival rates. Understanding the longitudinal distribution of temperatures in relation to the Restoration Flows on the San Joaquin River is critical to our ability to successfully prepare the system for reintroduction of Chinook salmon (i.e., evaluate site specific alternatives, make recommendations on water allocations, make recommendations for stock selection). The purpose of this report is to summarize temperature data collected during the Fall 2009 Interim Flow Period.

Methods

The California Department of Fish and Game (DFG) began collecting water temperatures during the Fall Interim Flow Period. Temperature data loggers (HOBO, Onset Corporation, Bourne) were placed at various locations beneath the water's surface, in a longitudinal array throughout the Restoration Area (geographic coordinates provided in Table 1). Location was dependent on an appropriate anchor point, the ability to conceal the loggers to reduce vandalism, and legal access (contact Eric Guzman, DFG, for more details about the location of individual loggers). Loggers recorded temperature hourly. This report summarizes discharge and air temperature conditions during the Fall Interim Flow Period (preliminary data from California Data Exchange Center; http://cdec.water.ca.gov, accessed on February 4, 2010) (Figure 1 and Figure 2), and water temperatures at locations immediately below Friant Dam downstream to Sack Dam (preliminary data from DFG). Temperatures were summarized daily, and by diel period (corresponding with approximate sunrise and sunset times during the Interim Flow Period). These data are preliminary and subject to revision. Errors in data are more likely to occur prior to or after the Interim Flow Period due to placement or removal of loggers.

Results

Water temperatures were relatively stable immediately below Friant Dam (Figure 3). Daily variation increased with distance downstream of the reservoir, but mean temperatures remained relatively consistent (generally 9 – 12 °C) (Figures 4-6) until approximately river mile 250. Temperatures from river mile 250-256 (mining pit locations) indicate less variation in these areas, but higher temperatures (Figures 6-9). Data appear relatively consistent between loggers in different locations within the same mining pits (Figures 8-9). The coefficient of variation was much greater in the mining pits downstream to Sack Dam than upstream reaches more influenced by the reservoir (Table 2). Maximum temperatures were higher in the river channel associated with mining pits than the other reaches (Table 2). There were no apparent diel differences in mean temperatures (Table 2). Daily variation in river temperatures increased downstream of mining pit locations (Figures 10-12).

Discussion

It is difficult to evaluate the impacts of interim flows on temperatures during the fall period. Ambient temperatures were dropping throughout the Interim Flow Period thus complicating interactions between water temperatures and changes in discharge conditions. The Spring Interim Flow Period will likely provide more insight to the influence of discharge on the water temperature regime in the San Joaquin Restoration Area.

Water temperatures during a portion of the Fall Interim Flow Period correspond to the period of time when spring-run Chinook salmon are expected to be spawning (likely through the end of October; Fisheries Management Work Group 2009). If we assume spring-run Chinook salmon can make a successful migration to holding pool habitat in the upper reaches of the San Joaquin River, it appears (based on 2009 data) water temperatures would be appropriate for spawning and egg incubation (15.6 °C is the limit for spawning and egg incubation; USEPA 2003) above river mile 256. Regardless of suitability of other habitat conditions, water temperatures below the mining pits (downstream of river mile 250) are likely not suitable for spawning, but could depend on exposure time, seasonal air temperatures, and subsurface water temperatures (which are likely cooler). Further, the specific locations of data loggers (i.e., near the stream margins versus main channel) may also complicate our ability to make firm conclusions. More data should be gathered from these downstream habitats, and over multiple years, to better address our understanding of the temperature regimes in these locations. Water temperature and other physical and biological measurements of the hyporheic environment should also be assessed in potential spawning areas.

Water temperatures during this Interim Flow Period also relate to the migration timing of fall-run Chinook salmon (likely throughout the period of time defined as the Fall Interim Flow Period). The EPA defines temperatures less than 18 °C as appropriate for migrating fall-run Chinook salmon (USEPA 2003). Using this temperature as the upper limit, the 2009 data indicate most locations sampled would be appropriate for fall-run salmon migrations. The water temperatures in the mining pit areas downstream to Sack Dam are warmer than this upper limit, but for a relatively short duration and primarily between river miles 250-256. The implications of these temperatures for successful migrations are subject to the same caveats made above for spring-run Chinook salmon.

Although data during the Fall Interim Flow Period were limited, a cursory comparison of measured surface temperature and HEC 5Q modeling estimates (Water Management Work Group 2008, Temperature Model Sensitivity Analyses Sets 1 and 2 Draft Technical Memorandum) was made. Observed temperatures below Friant Dam (river mile 266.6) during the month of October was less than 10 °C, and observed average temperatures at river miles 234.5, 204.5, and 182 were lower than the HEC 5Q estimates (see Figure 3-3, page 3-5 of Temperature Model Sensitivity Analyses Sets 1 and 2 Draft Technical Memorandum). Water temperature during spawning and incubation for spring-run Chinook salmon was identified as a primary limiting factor in the Fisheries Management Plan, Conceptual Model (Fisheries Management Work Group 2009). Though these results are preliminary and based only on one year and season of data, the actual water temperatures during October in the spawning reach appear more favorable than originally predicted (those we fully acknowledge this is simply a broad look at one year of data compared to modeled means). The Fisheries Management Work Group will continue to assess water temperatures during the spawning and incubation period and adjust the limiting factors analyses as appropriate.

Because the temperature fluctuations and maximum temperatures were substantially higher from the mining pits downstream, we have placed vertical arrays of temperature loggers in some of these locations to document vertical temperature distributions through future Interim Flow Periods. This information may indicate if there are cooler-water pockets (i.e., stratification, local groundwater influences) in some of the mining pits and downstream areas. Additionally, we will continue to monitor longitudinal temperatures patterns during future Interim Flow Periods to identify the annual variation in water temperatures throughout the Restoration Area.

References

California Data Exchange Center; http://cdec.water.ca.gov, accessed on February 4, 2010

Fisheries Management Work Group. 2009. Draft Fisheries Management Plan: A Framework for Adaptive Management in the San Joaquin River Restoration Program. San Joaquin River Restoration Program.

Fry, F.E.J. 1971. The effects of environmental factors on the physiology of fish. Pages 1-98 *in* W.S. Hoar and D.J. Randall, editors. Fish Physiology. Academic Press, New York.

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U.S. Environmental Protection Agency (USEPA) 1999. A review and synthesis of effects of alterations to the water temperature regime on freshwater life stages of salmonids, with special reference to Chinook salmon, EPA 910-R-99-010, 279 p.

U.S. Environmental Protection Agency (USEPA) 2003. Environmental Protection Agency Region 10 Guidance for Northwestern State and Tribal Temperature Water Quality Standards, EPA 910-B-03-005, 49 p.

Water Management Work Group. 2008. Temperature Model Sensitivity Analyses Sets 1 and 2. Draft Technical Memorandum. San Joaquin River Restoration Program.

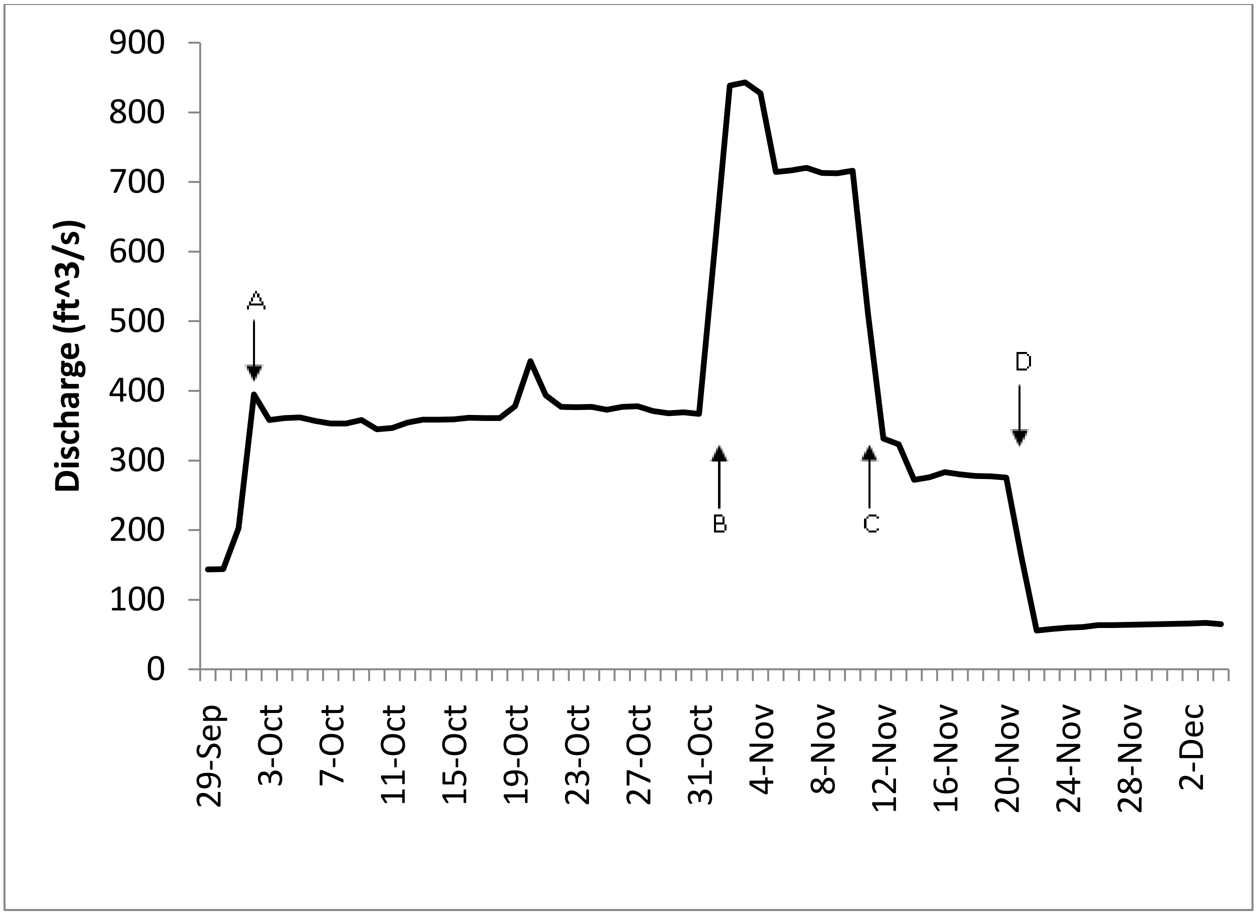

Figure 1.- Discharge (ft^3/s) in the San Joaquin River, below Friant Dam from September 29 through December 4, 2009. Letters indicate: A- Beginning of Fall Interim Flow Period; B- beginning of 750 ft^3/s release; C- return to 350 ft^3/s release; D- end of Fall Interim Flow Period.

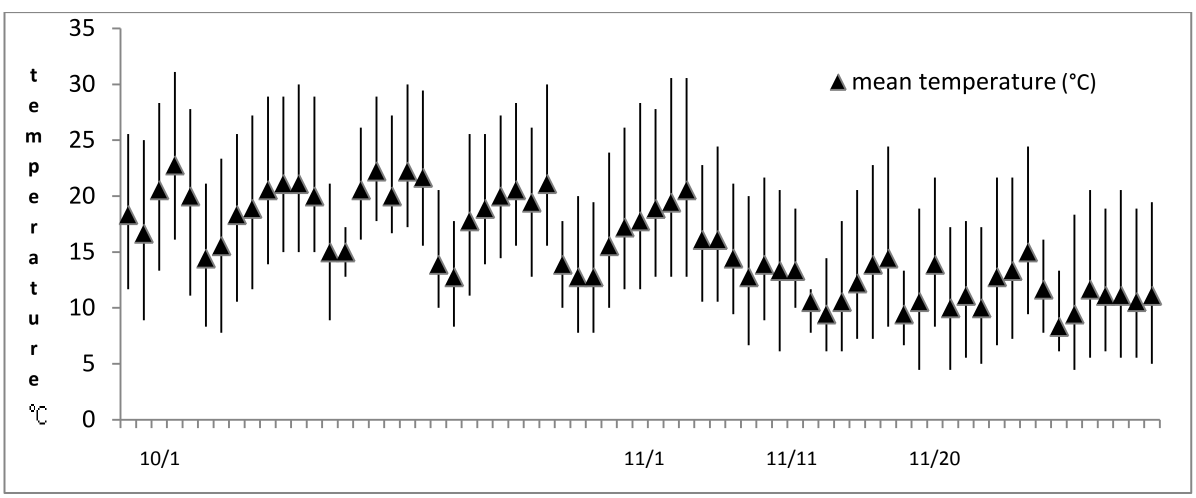

Figure 2.- Air temperature conditions (daily minimum, maximum, and mean) at Friant Dam during the Fall Interim Flow Period (data from California Data Exchange Center, subject to revision).

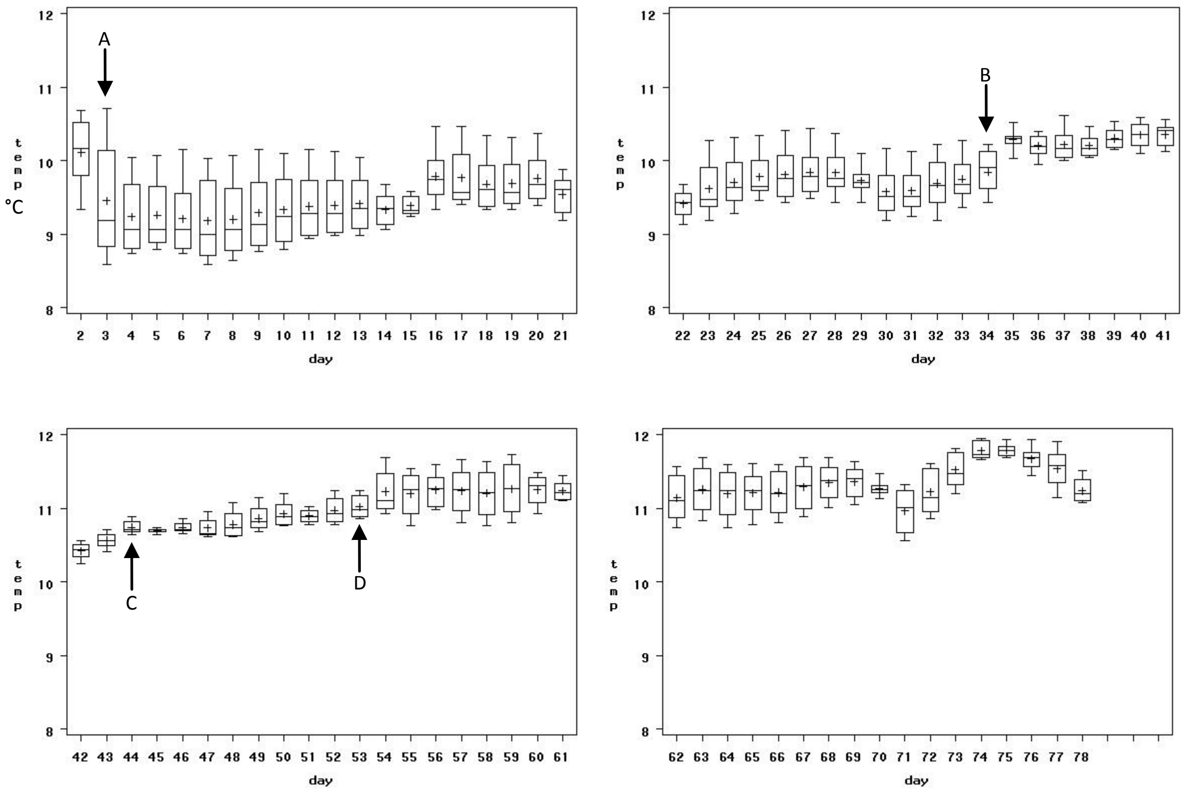

Figure 3.- Water temperatures (°C) recorded near the bridge below Friant Dam (river mile 266.6). Box plots depict mean (+), quantiles (25%, median, and 75%) and minimum and maximum water temperature, by day. September 29 is day 1 and December 15 is Day 78. Dates corresponding to the Fall Interim Flow Period are represented by A-D as presented in Figure 1.

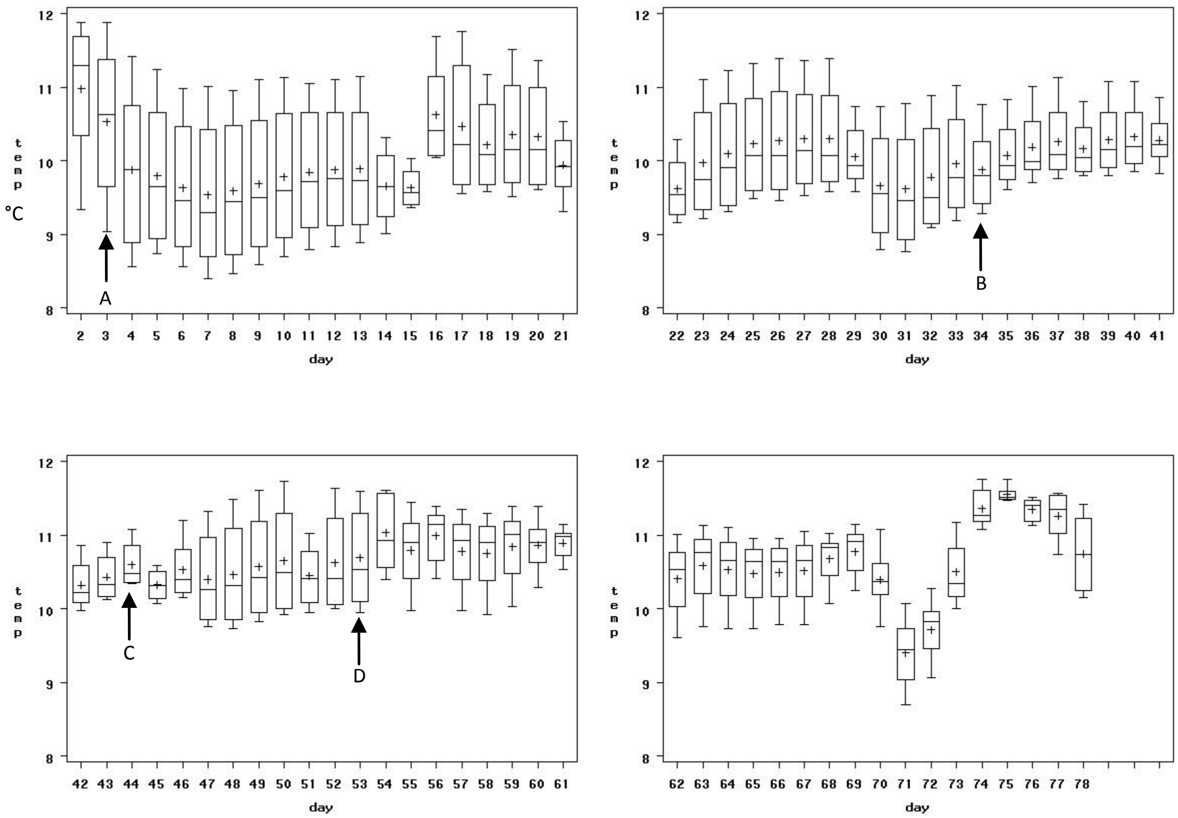

Figure 4.- Water temperatures (°C) recorded near Lost Lake Park (river mile 264.7). Box plots depict mean (+), quantiles (25%, median, and 75%) and minimum and maximum water temperature, by day. September 29 is day 1 and December 15 is Day 78. Dates corresponding to the Fall Interim Flow Period are represented by A-D as presented in Figure 1.

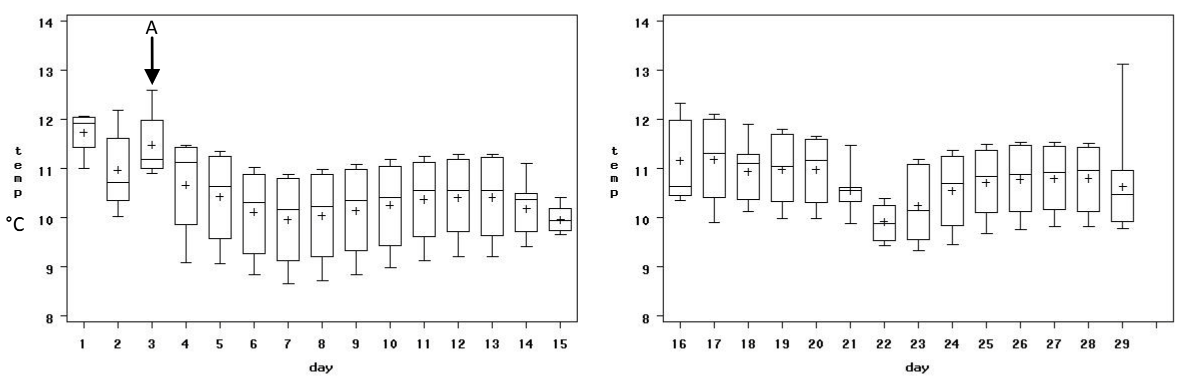

Figure 5.- Water temperatures (°C) recorded in what is perceived to be holding pool habitat (river mile 262) for adult Chinook salmon (river mile 262). Box plots depict mean (+), quantiles (25%, median, and 75%) and minimum and maximum water temperature, by day. September 29 is day 1. Dates corresponding to the Fall Interim Flow Period are represented by A-D as presented in Figure 1. Data were truncated during the period due to unforeseen circumstances (i.e., possible vandalism).

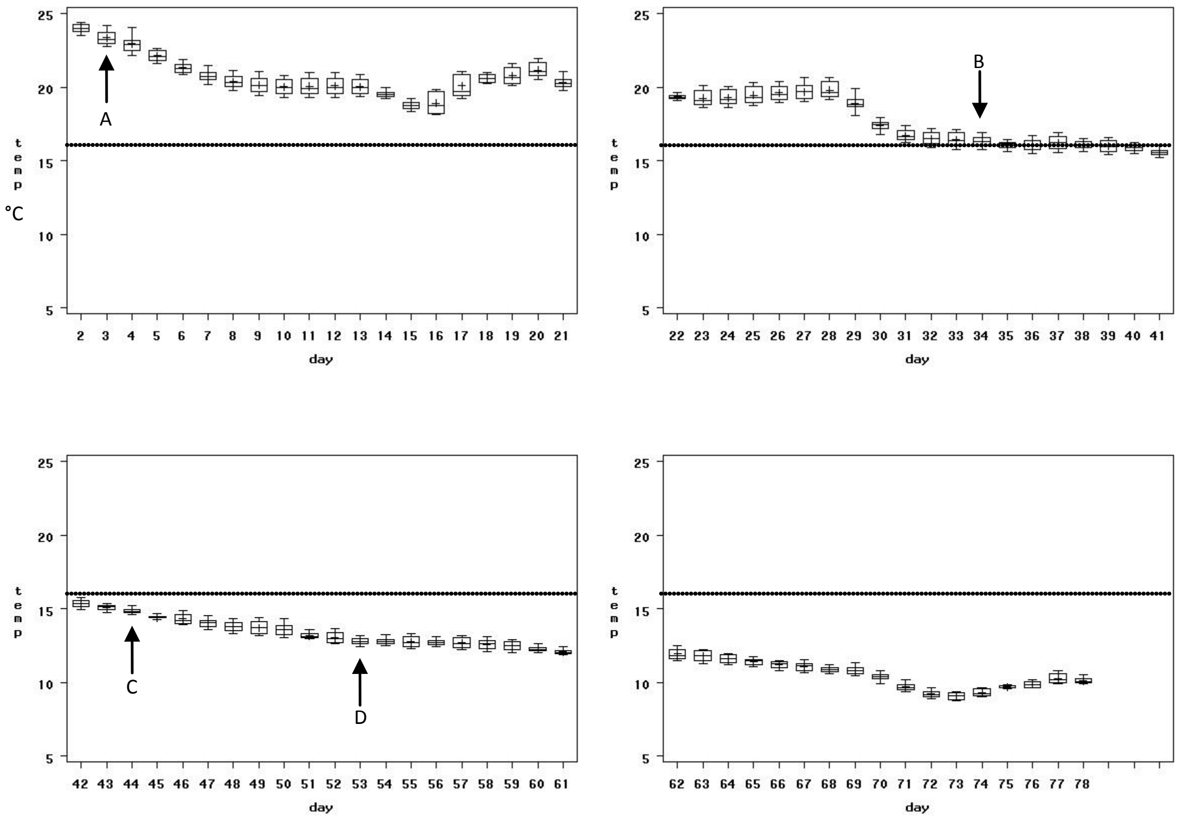

Figure 6.- Water temperatures (°C) recorded from in-river mining pits (gravel pit A, river mile 250-256). Box plots depict mean (+), quantiles (25%, median, and 75%) and minimum and maximum water temperature, by day. The dashed line indicates the temperature limit set by EPA for spring-run Chinook salmon spawning and egg incubation. September 29 is day 1 and December 15 is Day 78. Dates corresponding to the Fall Interim Flow Period are represented by A-D as presented in Figure 1.

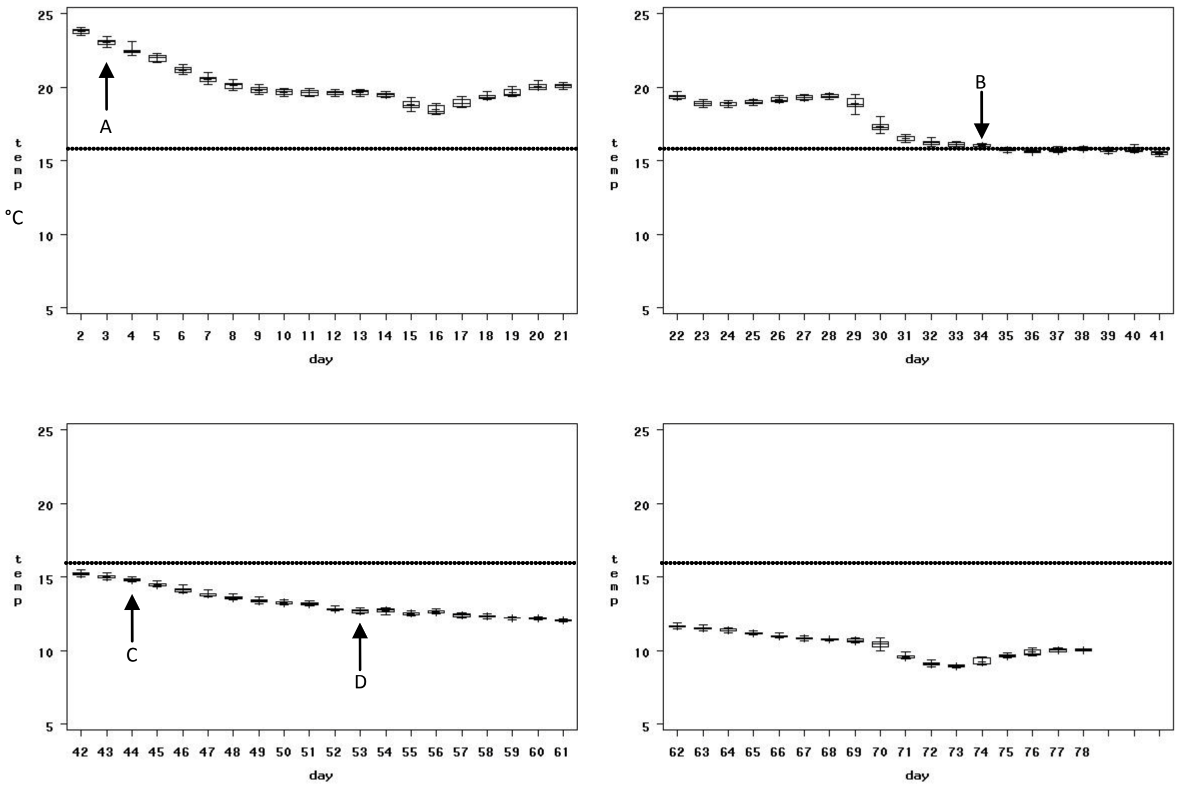

Figure 7.- Water temperatures (°C) recorded from in-river mining pits (gravel pit A, river mile 250-256). Box plots depict mean (+), quantiles (25%, median, and 75%) and minimum and maximum water temperature, by day. The dashed line indicates the temperature limit set by EPA for spring-run Chinook salmon spawning and egg incubation. September 29 is day 1 and December 15 is Day 78. Dates corresponding to the Fall Interim Flow Period are represented by A-D as presented in Figure 1.

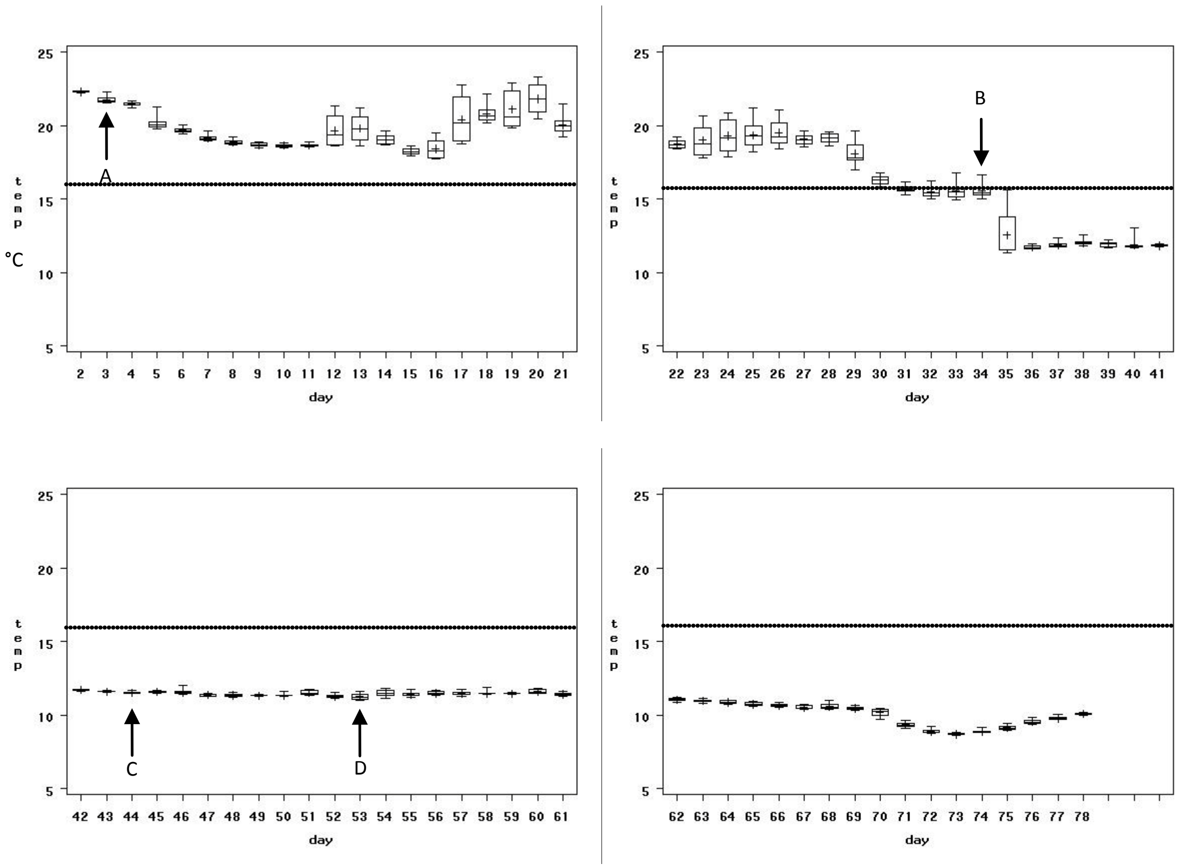

Figure 8.- Water temperatures (°C) recorded from in-river mining pits (gravel pit C, river mile 250-256). Box plots depict mean (+), quantiles (25%, median, and 75%) and minimum and maximum water temperature, by day. The dashed line indicates the temperature limit set by EPA for spring-run Chinook salmon spawning and egg incubation. September 29 is day 1 and December 15 is Day 78. Dates corresponding to the Fall Interim Flow Period are represented by A-D as presented in Figure 1.

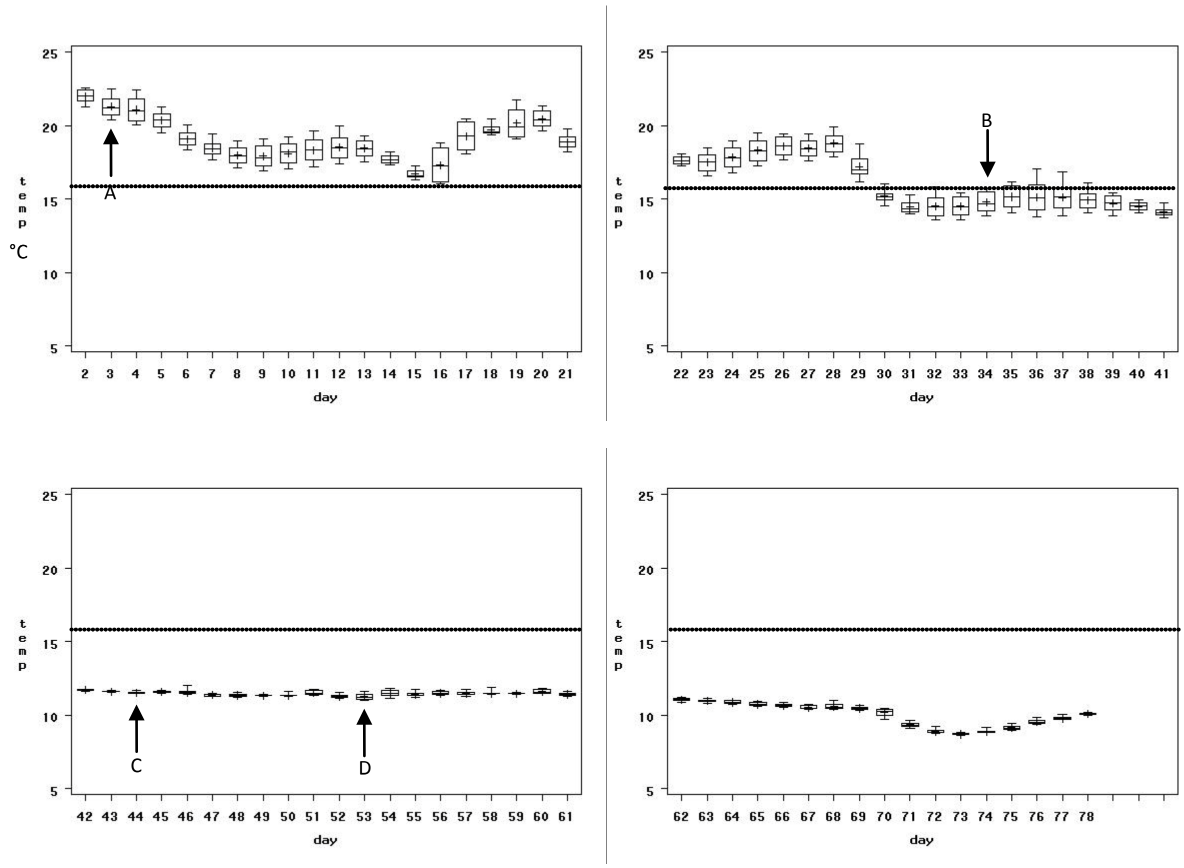

Figure 9.- Water temperatures (°C) recorded from in-river mining pits (gravel pit D, river mile 250-256). Box plots depict mean (+), quantiles (25%, median, and 75%) and minimum and maximum water temperature, by day. The dashed line indicates the temperature limit set by EPA for spring-run Chinook salmon spawning and egg incubation. September 29 is day 1 and December 15 is Day 78. Dates corresponding to the Fall Interim Flow Period are represented by A-D as presented in Figure 1.

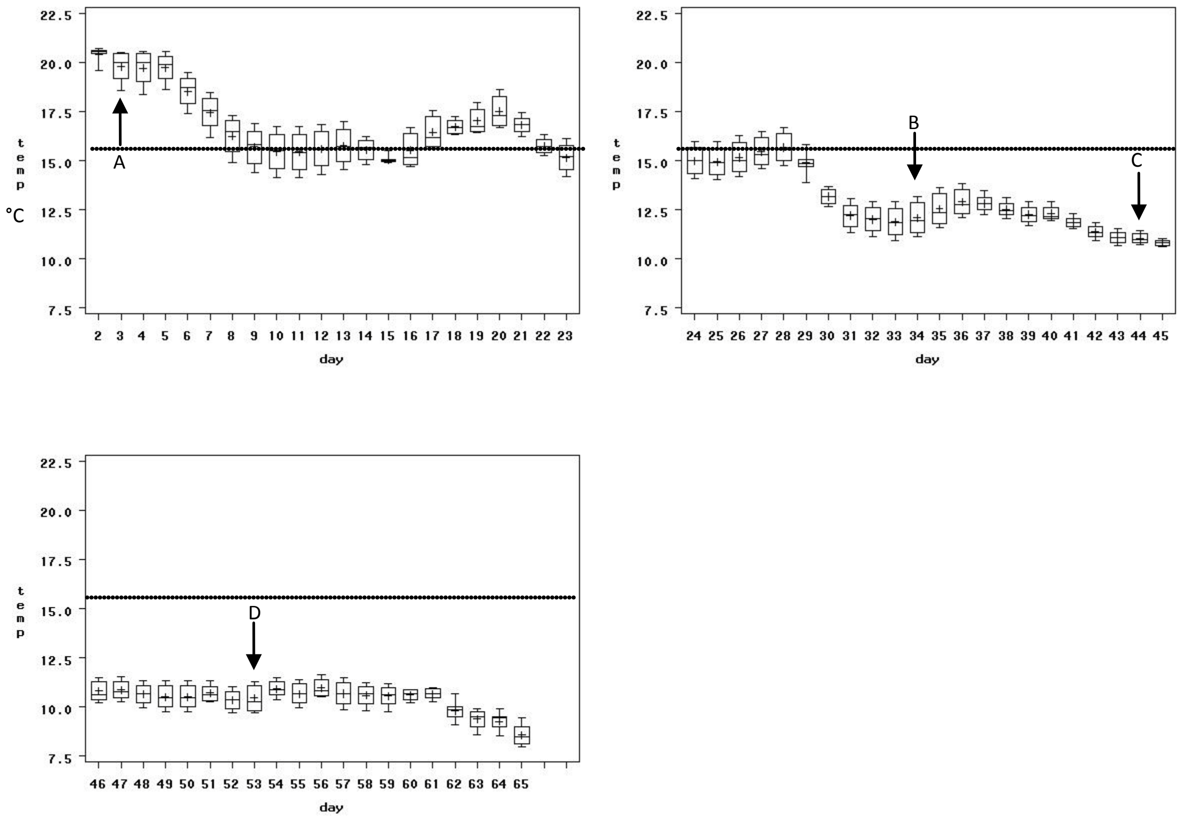

Figure 10.- Water temperatures (°C) recorded in the San Joaquin River, upstream of Skagg's Bridge (river mile 234.5). Box plots depict mean (+), quantiles (25%, median, and 75%) and minimum and maximum water temperature, by day. The dashed line indicates the temperature limit set by EPA for spring-run Chinook salmon spawning and egg incubation. September 29 is day 1. Dates corresponding to the Fall Interim Flow Period are represented by A-D as presented in Figure 1.

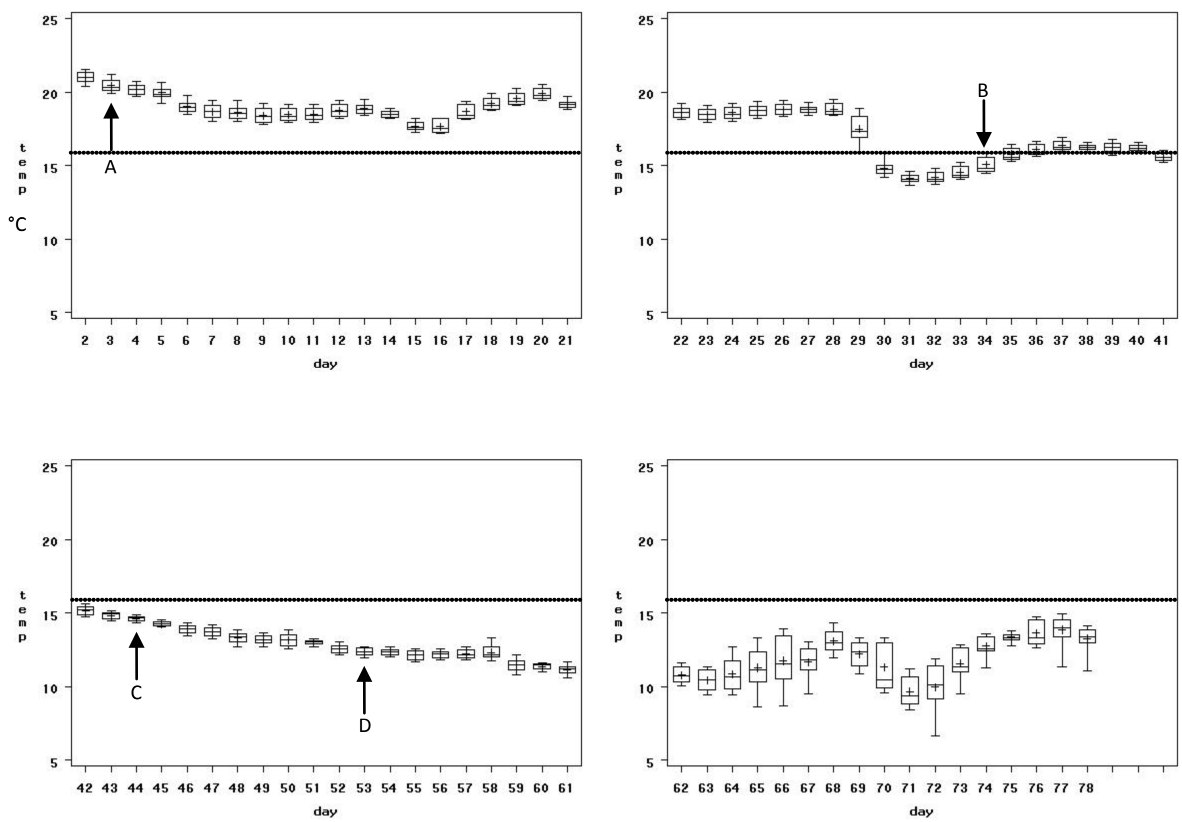

Figure 11.- Water temperatures (°C) recorded at Mendota Pool (river mile 204.5). Box plots depict mean (+), quantiles (25%, median, and 75%) and minimum and maximum water temperature, by day. The dashed line indicates the temperature limit set by EPA for spring-run Chinook salmon spawning and egg incubation. September 29 is day 1. Dates corresponding to the Fall Interim Flow Period are represented by A-D as presented in Figure 1.

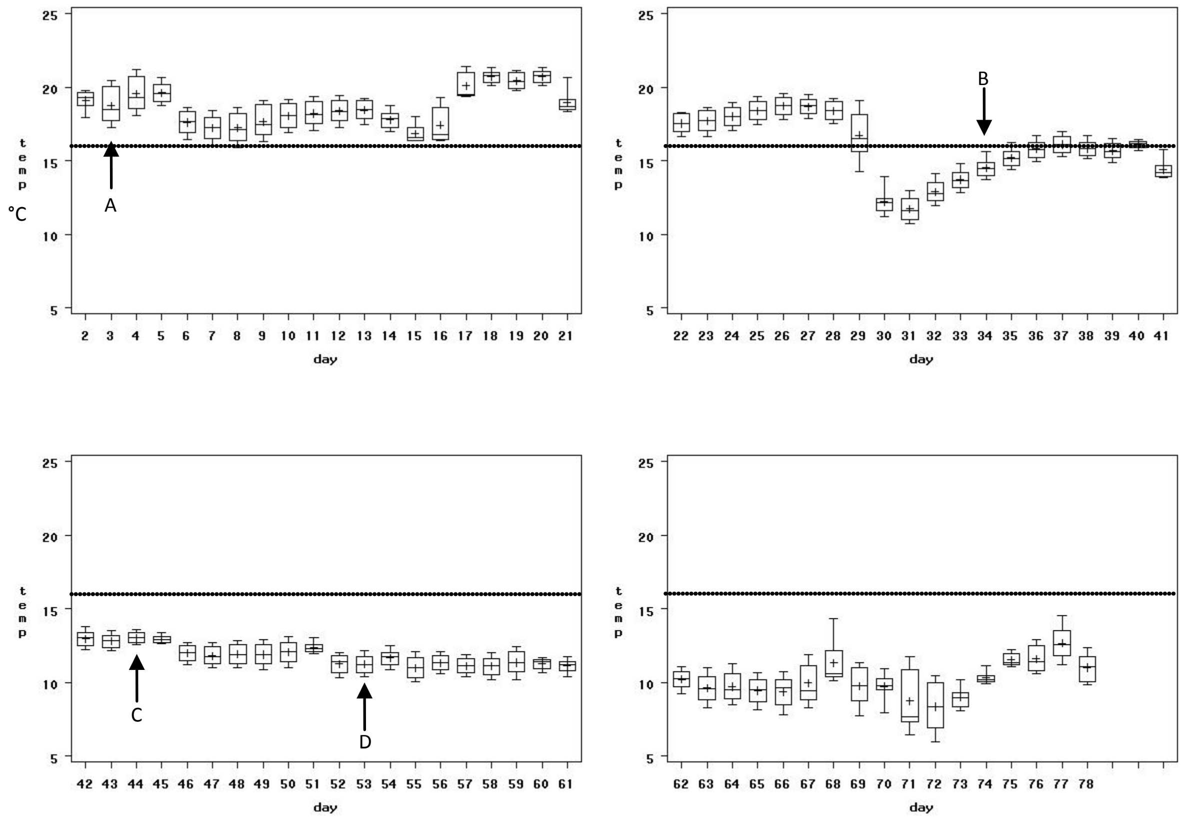

Figure 12.- Water temperatures (°C) recorded at Sack Dam (river mile 182). Box plots depict mean (+), quantiles (25%, median, and 75%) and minimum and maximum water temperature, by day. September 29 is day 1. The dashed line indicates the temperature limit set by EPA for spring-run Chinook salmon spawning and egg incubation. Dates corresponding to the Fall Interim Flow Period are represented by A-D as presented in Figure 1.

Table 1.- Description of temperature data logger location and geographic coordinates (longitude and latitude)

Location	Description	River Mile	Longitude	Latitude
Friant Dam	below bridge just below dam	266.6	-119.715041	36.990005
Lost Lake	downstream of Lost Lake Park	264.7	-119.740406	36.968959
Holding Pool A	upstream of Ball Ranch	262	-119.733614	36.947572
Gravel Pit A	downstream of 41 bridge		-119.80419	36.865392
Gravel Pit C	downstream of 41 bridge		-119.808525	36.860946
Gravel Pit D	downstream of 41 bridge		-119.811125	36.861132
Skaggs Bridge	upstream of bridge at Skaggs Park	234.5	-120.050977	36.821092
Mendota Pool	downstream of Mendota Pool	204.5	-120.371179	36.792138
Sack Dam	downstream of dam	182	-120.500043	36.985071

Table 2.- Means and associated summary statistics of water temperatures (°C) from below Friant Dam to Sack Dam during the fall Interim Flow Period. Coefficient of variation is represented by CV, river mile by RM, and 1 = day and 2 = night for diel period.

Diel period	Site	RM	Dates	Mean temperature	Standard deviation	Minimum	Maximum	CV
1	Friant Dam	266.6	9/30-12/15	10.49	0.77	8.6	11.93	7.31
2	Friant Dam	266.6	9/30-12/15	10.27	0.91	8.6	11.95	8.84
1	Lost Lake	264.7	9/30-12/15	10.44	0.72	8.39	11.78	6.94
2	Lost Lake	264.7	9/30-12/15	10.42	0.72	8.44	11.88	7.04
1	Holding Pool	262	9/29-10/27	10.4	0.93	8.6	13.1	8.8
2	Holding Pool	262	9/29-10/27	10.7	0.66	9	12.1	6.1
1	Gravel Pit A (1)	250-256	9/30-12/15	15.85	4.05	8.77	24.44	25.52
2	Gravel Pit A (1)	250-256	9/30-12/15	15.65	4	8.8	23.81	25.47
1	Gravel Pit A (2)	250-256	9/30-12/15	15.49	3.9	8.84	24.07	25.19
2	Gravel Pit A (2)	250-256	9/30-12/15	15.47	3.87	8.84	23.88	25.05
1	Gravel Pit C	250-256	9/30-12/15	14.48	4.29	8.64	23.33	29.63
2	Gravel Pit C	250-256	9/30-12/15	14.42	4.15	8.64	22.78	28.79
1	Gravel Pit D	250-256	9/30-12/15	14.77	3.68	7.89	22.59	24.91
2	Gravel Pit D	250-256	9/30-12/15	14.38	3.57	7.95	21.7	24.84
1	Skagg's Bridge	234.5	9/30-12/2	13.55	3.01	7.97	20.72	22.24
2	Skagg's Bridge	234.5	9/30-12/2	13.41	2.95	8.3	20.58	22
1	Mendota Pool	204.5	9/30-12/15	15.29	3.27	6.66	21.53	21.38
2	Mendota Pool	204.5	9/30-12/15	15.22	3.06	8.67	20.77	20.12
1	Sack Dam	182	9/30-12/15	14.14	3.62	5.96	21.32	25.61
2	Sack Dam	182	9/30-12/15	14.44	3.71	6.46	21.39	25.65